And Other Scientists: Stories of Women in Science

Creating an Imaginative Archive for Marginalised Women in Science

by

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Declaration

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Abstract

While recent decades have seen a corrective to longstanding omissions, historical archives tend to have placed women at a distinct disadvantage, consigning them to the margins. Though women may have made valuable contributions to their fields or lived incredible lives, their names are often relegated to footnotes, posthumous acknowledgements, or simply left out of the record all together. Via a collection of original short stories entitled *And Other Scientists: Stories of Women in Science*, along with an accompanying self-reflexive research essay, my study highlights some of the extent to which this has occurred in relation to the lives of important female scientists. Despite contemporary attempts at a more inclusive archive documenting the successes of women scientists, there remains a lack of recognition, a lack of equality, and a lack of popular knowledge about women's achievements in the male-dominated field of science. By combining creative and research components, my MA study attempts to bring into focus the names and achievements of selected women in science, animating these individual lives as more broadly representative of a larger group of unacknowledged female scientists throughout history. Drawing on the idea of re-storying in relation both to female lives and also to the notion of the Nature of Science (how science is understood) I overlap ideas from the fields of science and the literary arts, exploring why there still remains a lack of women in science and how this could be changed, while contributing to the developing and growing Women's Archives that intend to increase the visibility of women scientists whose names are left out of traditional archives.

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Creative Component

Metamorphosis

Maria Sibylla Merian (and her daughter Dorothea)

May 1699

I lurched on the deck of the *Aemilia*, my hands clinging to a lashed crate. The grey sea swirled; the deck heaved. A gust of wind almost caught my hat.

The weather was terrible but I had heard rumours of land and had braved my way up to see for myself. Keeping my hand firmly pressed to my hat I used the next roll of the ship to propel me towards the side, my burning eyes narrowed into the gale. Crumbs of salt crusted my lashes from the spray but through the misty air I could still see a murky lump on the horizon. *Land*. After months on this swaying wooden mountain my stomach vaulted at the thought of earth beneath my feet. A place so settled and certain. It would be some time yet before we disembarked, but just to see the looming outline, to glimpse the country we were to explore, was enough to lighten my heart. For now, at least.

"Where did you get to?" My mother's voice reproached me before I had even fully opened the door to our cabin.

"It's true!" I cried, stumbling as the ship tilted once again, "Land is in sight."

"Well, that is some good news," she said, gesturing me over to where she was huddled in a chair that had been wedged into the corner. My mother was looking well considering the months aboard the ship. Her greying hair was pulled back into a tight bun (a feat I could never understand, considering our lack of mirrors), and her lightly lined face glowed with a healthy flush, not like the nauseated faces of the first-time sailors I'd seen clinging to the ship's ladders.

"How long do you think it might be now?" I asked, seating myself on the bunk nearest her.

"Probably a good week still, I should imagine." Calmly she closed the notebook on her lap, "Not longer. We haven't been much delayed by the weather."

"I can't wait," I sighed, untying my hat beneath my chin. How battered it was! I silently despaired at the beating it had been given by the wind. "Can't you just see it, mama? Miles and miles of trees so green they look like they were painted by some great master! Birds that can't possibly be real but somehow, they are flying overhead, and creatures, oh wonderful creatures that hide in the underbrush, their fur in shades that can scarcely be replicated. I shall feel the whole time that I am in a sort of wonderland, some fantastical painting. Don't you think so?"

My mother rolled her eyes a little, gently reproaching my youthful fantasies. I was 21, after all. No longer a child. Perhaps I should have known better than to revel in imagination, for life had not been easy. We had moved around a great deal. From Nuremberg to the north of Amsterdam, though the religious community there had failed. Then, after mother left our father, we'd set up a studio in the city of Amsterdam, where my sister and I had become skilled, under our mother's tutelage, in the art of painting birds, plants and insects. We'd made a reasonable living, and mother's reputation was established, her contribution to the science of metamorphosis recognised. So mama might well expect me to know that living in a dream gave scarce space for the rigours of life. But while she spoke, I could see, by the sparkle in her look, that she too was excited to land. There was in her face a suggestion of the eager, thirteen-year old girl fascinated by the mysterious lives of butterflies.

We had sold up everything in the Netherlands, which had become too narrow to accommodate my mother's hungry desire for new subjects of scientific illustration. The jungles of South America were said to be teeming with specimens still unknown in Europe, and the Dutch colony of Suriname offered her an excellent chance to study material for a new book. And I knew, no matter what she told others, this was more than just a business trip for her. This journey was a chance to see things that some would never get to see, to find things others had never found, and to live, however briefly, in a wondrous natural landscape far removed from

the insistently neat order of the Dutch countryside we had left behind. Now, at last, the lush promise of the New World awaited, Suriname just a week beyond the waves.

June 1699

The sun was shining as we moored at the dock in Suriname, a small port beyond which waited the plantations and villages. As if this world was ours to explore. Mother and I were on deck, a warm breeze playing with the ribbons of our hats. Down on the quay thronged a noisy mass of people, their words obscured in the sheer volume of voices. All around us on the ship, crew bustled, hauling ropes and baggage, and shouting instructions. If you did not look at the specifics, it was much the same scene as in the harbour from which we had departed Holland, months ago. However, the heat almost immediately chased that thought, and taught its fierce lesson: a vicious sun beat down on us with the knowledge that we were very far from home.

Once I'd adjusted my eyes to the glare, and looked away from the turmoil of bodies, crates, and ropes, I sensed a new, exotic world. Even from the docks I could make out the intense, glowing green of sprawling vegetation. And in the far distance: the grey smudges of mountains.

After what seemed like the entire vessel had been disembowelled onto the docks below, it was finally our turn to disembark. My mother gestured for me to lead the way down the wooden ramp, and a fellow passenger kindly offered me his hand. For a moment I swayed above the churning water between ship and solid land, suspended, but my anxiety calmed when I glanced behind to see my mother nearby, grinning happily. We descended to the dock and it was like being dropped into a pit of noise.

Suddenly, I was completely surrounded by faces, voices, the strong smell of sweat. My mother had already found her feet; she was gesticulating at the captain who in turn instructed a crewman to dig through a pile of crates for what I assumed must be our luggage. I fought my

way over to her, ducking underneath arms and around boxes, everything jostling for space on the busy quay.

"Dorothea," she urged, as I approached, "*please*, we need to be going."

"I'm trying!" I took the stack of heavily wrapped notebooks that she shoved into my arms, "It's a little busy here, if you haven't noticed."

"Come on, bring them with you," she said, pointing out more of our baggage to a porter whose services she seemed to have secured.

"Excuse me, madams." A man emerged from the crowd. Tall, with pale hair and irritable, sun-blotched skin. At his haughty tone, the crowd melted away. A Dutch official of some kind. "May I see your papers?"

My mother nodded, smiling thinly. Carefully she placed the bag she was holding on the crate in front of her, while reaching into the smaller bag strapped across her body, extracting a waterproof pouch. From within this, she handed him a small bundle of papers.

"Maria and Dorothea Merian, travelling from Amsterdam."

The man peered over the top of his glasses, scanning the papers slowly.

"And you are travelling alone?" He raised a pale, caterpillar eyebrow.

"No," my mother replied, "I am travelling with my daughter, as I have just said. And she is travelling with me. As the documents indicate."

"But this place is not safe for decent ladies like yourselves," the man sniffed. "You would have been much better off remaining in Holland. What business could you possibly have here, in Dutch Suriname?"

"Oh, my business is also but a pleasure, sir. For I am here to study the local lepidoptera, found only here in Suriname," she smiled. There was a second's pause from the man, and I watched his expression with amusement. You could see his mind working furiously, frantically searching the recesses of his brain for some residue of knowledge that might reassert the upper

hand. My mother let him stew a while, casually claiming back our papers from his gawking grasp. “Caterpillars, butterflies, moths, and the like. My youngest daughter is here to assist me.”

“Of course.” The man coughed, abruptly raising a handkerchief to his wan lips, a sheen of sweat on his forehead. There was something sickly in the way the heat claimed his body. Like it had sunk under his skin, crept into his blood, into the folds of his skin. Like it did not want to be found, or expelled.

“We’ll be on our way now,” my mother said, gathering our bags about her once again. “If would be so kind, might you organise us some form of transport?”

Still disconcerted by her calm, slightly stinging attitude, the man nodded.

“Where are you heading, if I may?” he asked.

“Paramaribo,” I said quickly, and curtly he disappeared into the crowd.

Paramaribo. For the first time I said the word aloud. The name and my breath for just a second, joined. I felt myself on the verge of becoming someone different. Paramaribo. I had memorised the name months ago, pouring over a rough sketch of what we understood Suriname to look like, drawn by mother on a scrap of paper. It was the capital, a colonial city built on the banks of a tropical river that flowed ever inwards towards who knew where.

September 1699

It is hard to believe that we have already been here some three months. It is a strange landscape. Wet. Hot. Every day when I wake, even before the sun begins to bake the roof, I am aware that I am somewhere far from what I once thought was normal life. When we arrived, back in June, the rainy season had hit hard; days passed in hot tropical downpours. Slurries of rain. But, over the last few weeks the rain has eased, and a more intense heat has begun to rise, no longer kept at bay by the wind and water.

As the sun warms my room, this small space under the eaves of a plantation house becomes quickly unbearable. Then I wash my face in a jug of water that is already too warm to be refreshing, and I head below, into the main house. My mother will be outside, for she detests being in this house more than she is obliged. She has come to hate the planters, and their obsession with the stifling swathes of sugarcane that surround the homestead, stealing air, life, ideas. She spends much of her time trying to speak to the slaves, and to the indigenous people who have been pushed back into the dwindling forests by the men who clear their land with religious devotion. Even as I walked across the gap that had been cut between the house and the forest beyond, the sound of trees being felled echoed in my ears. The mountains behind the house were changing every day, the trees disappearing in huge waves, leaving behind bare rock and naked ground. The scene painted an ugly picture across the horizon. And all of this rapacious timber was to feed the sugar boilers, machines which ate and ate, day and night.

"Good morning," I called, waving to a tall figure in the field. Eugène. The foreman for the planters. A quiet man, he seldom replied, although I was never sure why. Did he not understand what I was saying, or did he see me as just another white person, part of the problem, a symbol of the disappearing forests he had watched grow? I hoped it was the former, even if that stretched belief. As I passed, he merely nodded solemnly and continued his inspection of the land.

I found my mother just beyond the boundary of plantation and jungle, on a narrow path that wound into dense vegetation. She was seated on the ground holding a plant, the roots trailing from the stem. With her was Albertina, a local Surinamese woman she had become quite friendly with. My mother was peering at the leaves, turning them over; bending them to test their flexibility. I was always amazed at how long she spent on a single plant, studying the details. There was no way to know how many minutes or hours she had been here already, but she would not be leaving any time soon. As I approached her, my shoe caught in a vine and I

almost tripped, and she looked up at the rustle of leaves. Her face was cast in shadow by her hat, dappled by the foliage overhead.

"Dorothea!" She beckoned. "You must see this."

I knelt down, and nodded at Albertina, who smiled. I had come to know this as her greeting. She seemed about the same age as my mother, and I found it strangely absorbing to see the two women in contrast. One in a neat, though dirt-stained navy dress, her greying hair beneath a tightly bound hat. The other, bare footed and bare-legged, her thick dark hair framing a wide, suntanned face. Two women from different worlds. Here together. Both lives revolving around the earth of plants and creatures.

"Albertina was just explaining to me about this…" My mother held out a plant, root first. "Cassava. Apparently, it is being used more and more by the planters, but the local people harvest these roots to bake into breads."

"Bread?" I took from her an odd-looking thing with a short stumpy stem topped with bright green leaves like a little umbrella. The roots formed the bulk of the brown growth. They looked like fat, mis-grown carrots spreading out from a single stem in a circular clump. At least eight big roots on this plant alone, each the length of my hand.

"They are made into some manner of flour, Albertina?"

"Yes, yes," Albertina, nodded firmly, rubbing her fingers against her thumb as though to indicate a fine powder, "Not like your weak bread in the farmhouse. Much more flavour."
I lifted the root to my nose and tried to get a sense of what she meant, but Albertina quickly pushed it away from my face.

"Don't eat now! It must be cooked first." Concern creased her forehead. "If you do not make it the right way you will be very sick."

"Well, it is certainly of interest," I said, relinquishing the root to Albertina's waiting hand and wiping my hands on my skirt. "And what else?"

"What else! Is this cassava not enough? my mother teased, breaking off an entire leaf stem, with buds and fully opened leaves attached, placing it carefully between the pages of her notebook.

Albertina left us, and I pressed mama for more. "What curiosity brought you to this plant? What *creature?* For I know there is a bug you must have liked, and whose trail you must have followed!" She paused for a second, then laughed.

"Well, since you persist!" She picked up a few papers from the ground, revealing several rough sketches. "Look at this beautiful specimen."

She had drafted several quick drawings. A series of caterpillars covered in some species of spiny hairs, and the outlines of various pupae.

"It looks to me we will see a beautiful butterfly from this. The pupa is actually a reddish colour," she said, touching a finger to a sketch, the charcoal smudging a fraction, blurring and sliding across the smooth paper into a slightly ragged form.

"Is this a new pupa you have found?" I asked eagerly. Her eyes shone.

"I believe it might be, yes." She took the pages and carefully slid them back into her field notebook. "But there is no rushing this process; we will just have to wait and see what comes out of the cocoon, when the time is right."

January 1700

Mother is ill again. She has been more affected by the sicknesses than I, but perhaps that is because she spends so much time outside, no matter the weather. I tell her that when the rain is coming down in sheets she should stay indoors, but she will not let a single day go to waste. She insists on heading into the forests even when the ground is turned to mud; even when the winds strip the leaves from the branches. And of course, I understand, for outdoors offers extensive pleasure. When I went with her last time we saw a pond full of minuscule, brightly

coloured frogs, newly transformed from the squiggly tadpoles we had been observing for weeks. These newly-minted miniatures were testing their fresh back legs, as if out jumping the rain.

But today, mama is staying indoors. I have managed to convince her to work on some of the finished drawings she has been planning. For we have hundreds of pages now: of caterpillars and tadpoles; the brown and white butterflies that we saw drifting around the cassava plants. Still: I hope the rainy season will subside soon, so that mother feels encouraged towards fieldwork. But for the present, we must remain quiet, inside. She needs to recover from whatever current sickness ails her. She is not herself.

May 1700

We have spent most of this month detailing a plant known here as Ananas ('pineapple' I believe it is called by some of the Dutch colonists). It is an odd one, like most of the strange things we encounter here.

"Dorothea!" my mother called out to me one day, where she was stopped in the grass, studying an Ananas fruit. "Look at this."

I crouched down and mistakenly went to pick the fruit, halting just in time to spot what my mother had seen. On the curious brown and yellow skin of the Ananas, almost an armour pieced together from domed scales, a tiny caterpillar was worlding its way across the surface. I looked up at mama in delight, but although she was still standing, bent over slightly to squint at the fruit on the ground, she was clearly unsteady.

"What a beautiful little fellow," I said, helping mother to sit on the ground. I should then have been digging out the sketch books, but my mind was suddenly awry. Mama would not admit it, but the recurrent series of sicknesses had taken their toll. She was tired. She often had dizzy spells. I'd thought for some time that we should be organising to return home, but

she railed against this plan. She insisted that we stay at least through the next wet season before we think about leaving. And mother being mother, that was that.

The caterpillar on the Ananas was pale green, with red and white stripes along the length of its body. From the red stripes rose plantlike spines, reaching a thumb's-length into the air. It was so beautiful. Fantastical. We had been in Suriname almost a year and I still found myself captivated by this different world. Every new plant promised something out of a fairy tale, every insect seemed a creature only spoken about in unlikely stories. Perhaps I should have known that such tales were not really meant for children.

A few weeks later we revisited the Ananas fruit patch, to see if the caterpillars had begun the next phase of their transformation. We searched in the grasses and on the leaves and at last discovered the strangest pupa we had yet seen. Given how vibrant the caterpillar had been we expected a jewel-like pupa, ruby-coloured, or emerald, but instead there was a dull, greyish brown oddity. A bony growth suspended by a thin thread from a leaf. It struck me as both marvellous and absurd, this fragile life hoping to grow into a world.

Mama and I started to sketch, and after a while Albertina came by to join us. She did not speak much when I was around, though she seemed to feel a definite kinship with my mother. She liked to sit and watch us draw. After a short while, she unwrapped a ripe ananas fruit and began to peel off the scaly skin with a small knife. Then *we* paused to watch her, so deft in her work, her hands quickly revealing a succulent, bright yellow flesh that dripped juice down her wrists. She sliced, and offered pieces to us. I almost spat when the Ananas touched my tongue. An acidic flavour unlike anything I had ever tasted. Strong and rich and sharp, all at once. Like citrus but somehow sweeter; never as tart as a lemon.

"Incredible," my mother said, through a mouthful. "It's like …?"

"Like all the fruits I've ever eaten, all combined!" I laughed at my own improbable description, and ventured tentatively to try another piece. My mouth would decide.

"What an extraordinary thing," my mother said, still savouring. Albertina just laughed quietly to herself, clearly relishing our perplexed delight.

A little more than a week after we had first found the pupa on the Ananas, my mother shook me awake. Much like every other morning, I was roused before sunrise, the air still chill, the sun still asleep. Mama was determined. She insisted we visit the pupa every day so that we might have the best chance of capturing the butterfly's emergence. We had searched for more of the strange cocoons but found none. So, this one we could not miss.

I think she and I were drawn to this odd transformation for the same reasons, wanting to see one small life cycle in Suriname all the way through. Start to finish. As if this complete process could make everything whole.

For this colony was a peculiar and violent place, marked by frequent disruptions. Some few people in positions of extreme mastery, and many others in terrible servitude. Following my mother's wishes we spent little time with the Dutch people who had settled here. We lived in a Dutch homestead, yes, but close to the jungle, and this allowed us to visit an otherworldly place, closer to other lives.

Still, we are cut off from the jungle, made to watch as it disappears, giving way to strict fields and monstrous sugar boilers. The people who live in the jungles and villages beyond the fences are watching us. Watching their country transform into unfamiliar territory. They watch me as I try to communicate that I am not like the men and women in the big houses and see me only as a part of the machines that pump the smoke of the dead trees into the once clear skies.

In amongst the ancient trees and the undergrowth, the creatures try to maintain their seasonal paths, and after the rains, plants push up through the earth, undeterred. As fast as a path is cut, scraggly vegetation reclaims it, though never with the deep roots of what once was.

I have wondered recently, once we leave, if we will ever return to see this place. It is changing, even as we look. I wonder what it would have looked like before us. What it might look like years from now. This is a transformation I will not be able to see all the way through. Perhaps this is not something I should even imagine.

We had often been able to follow the full metamorphosis of a butterfly back home in Amsterdam, as we kept caterpillars in special contraptions inside the house, specimens brought to us by merchants and travellers as subjects for my mother's paintings. But in the jungle, with the unpredictable weather and the tropical fevers laying mother low, we had struggled in our search to find the same type of pupa twice. I think, for both of us, then, there was something especially appealing about the possibility, however slim, of maybe seeing an unfamiliar butterfly emerge in its own right nature, struggling to unfold against the open sky instead of in a cloistered box in a dimly lit drawing room

The dark mass of the jungle was tinged at the edges in grey, the sky a blank canvas gradually washed in shades of light. No clouds. So you could tell already that the day would emerge hot. We reached the Ananas plant where the strange chrysalis dangled, and settled ourselves on the grass. My mother spread out her skirts (like unfurling wings, I for a moment fancied) and arranged her sketch books. I unwrapped the bread and fruit, and then we waited in the near-darkness. Minutes passed. The shapes around us slowly became more distinct, greys turning to pastels, hues eventually brightening into colour. Leaves rustled in the distance and birds called out from within the canopies. Ahead, the shadowy expanse of the jungle crouched on the horizon; behind it the sky, now streaked in orange blaze.

I was gripped by a fascinated mesmerism; I felt sleepy, leaning forward, my elbows resting on my knees, blinking my eyes awake. I had to remind myself to fix my attention on the object of our morning expedition: the little pupa. Waiting for change.

Just as the first rays of warming sun fell across the spiky Ananas crown, the chrysalis twitched. I reached a hand towards my mother, who edged closer, and together we bent our heads.

“Perhaps a slight breeze?” I whispered. But my mother raised a finger to her lips and shook her head. And then there it was again. A decided quiver.

Slowly the jerking became more frequent, and more fluidly convulsive. The membrane of the chrysalis stretched and deformed, showing the struggling shape within. Gently there started a gradual pendulous swinging, and the bony enclosing structure began to break apart. From within emerged a damp, crumpled insect, a slender thorax that appeared to drag behind it, like an impossibly heavy, water-drenched cape, a hobbling, scrunched mass of wings. The frail body was covered in tiny, feather-like hairs. Painstakingly this dull, bedraggled creature, still unabled of its wings, crawled grotesquely up the leaf into a gleam of sunlight. Exhausted, it rested, and my own breathing was suspended from its difficult progress. Then with great effort it shuffled and wriggled and almost imperceptibly, with every second it turned, slow muted colours started to show.

After a few minutes the butterfly’s wings opened, trembling, shaking off the damp. With one almighty flutter the wings snapped open. Then shut. And open. My mother and I gasped. Like sun on grass on the hottest day of the year the dark wings were sprayed with luminous colour. Bright green symmetrical patterns reflected back at us, flashing like a signal light as the butterfly opened and closed its wings. My mother could barely look away, her pencil slipping and sliding over the paper propped under her hand.

I sat, suddenly child-like, with my chin resting on her shoulder as she worked, watching the rapid strokes of her pencil. Soon her page was filled with sketches: the caterpillar and the unripe ananas fruit, lines crawling towards the pupa clinging to the centrefold, and now, as though flying off the page, the fever dream of the butterfly itself, transformed. And I felt that whatever else was to come, in Suriname, this one moment, just this one, was complete.

Seeing Stars

Cecilia Payne-Gaposchkin

Warm sand beneath my feet. I stood a little apart from the others, looking out at the ocean. The beach was otherwise empty, pale sands stretching out for miles and miles, nothing to break the silent untouched surface. Behind me, I knew, was the small group of researchers, huddled together around tables of equipment. But from this angle there was nothing but sea and sand. So far and so unfamiliar, compared to the grey, boxed in streets of home.

"Miss Payne?"

I reluctantly turned and saw a figure approaching across the sands

"Sorry to disturb, but the demonstration will begin soon," the young man said.

In the grey of the morning, I could barely see his face, but some glancing light from the sky glimmered in his eyes, the way that water reflects candle light, little waves in the dark. "I was just lost in thought. This place is something else."

"You're telling me," he said, "I'd never seen the ocean until this trip."

"You never went to the beach before?"

"Not once," he said, as we started to walk towards the others, "I've been in the city all my life."

I felt reassured. "To be honest, this is my first time seeing the sea as well. And it seems so strange and yet somehow familiar."

He laughed, and stumbled in the sand. I reached out to grab his hand and he almost took me down with him. Swirling high above us stretched the sky, the sun pouring over the horizon. I had the surreal sense of time passing around me, as the bright sphere streaked in liquid strata across the skies.

"I'm so sorry; I almost made you fall!" The man's laugh rang out brightly into the brightness of the day. I could not help but join him, and as he pulled himself up, we both stumbled again.

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When we reached the small group around the fire, my legs were instantly hot and I felt my cheeks flush at the sudden, intense warmth of the flames.

"Thanks for joining us," a deep male voice said. The famous man we were gathered there to see. Sir Arthur Eddington. I glanced towards the voice.

"Cecilia," he said, turning to me in the semi darkness. He was tall, thin, with a narrow face and pale hair that looked silver in the early light. I suddenly saw that he resembled the handsome young man who had come to call me from the edge of the water, and who had then disappeared back into the group, as if he had been but a specter. I felt myself looking around, uncertain. Next thing, Sir Eddington was reaching out a hand, warm and firm, pulling me forward.

"You must see this. *You* should be the one to see this." He led me towards a telescope set up in the sand.

"What am I looking for?" I asked.

"You will see," he said, somewhat cryptically. "The eclipse will begin soon, and then all will be clear!"

The bright circle of the sun, framed by the telescope, was slowly eaten by shadow. Like an eye closing.

"Now look further," Sir Eddington whispered. The telescope tracked across the sky and instead of the darkness I anticipated, the eyepiece filled with colour, swam with variable spectra. The sky became a rich navy blue, deeply shot through with greens and pinks, and amongst the paint-like swirls gleamed vibrant pin pricks of light. Starry constellations scattered

across the sky in configurations of alluring possibility and confounding perplexity. Everything seemed so remotely far above my reach.

My chest began to tighten. My heart beat, beat, beating loudly in my ears. My blood thumped and pumped yet my lungs seemed to be filling with water or gas or some mysterious substance that stopped me from drawing full breath. Dark circles pooled in my eyes, in front of the stars, blocking them out. I needed to breathe. I struggled to pull away from the telescope but it seemed fused to my face. I had the sensation that someone was squeezing my chest, wrapping their arms around me with a powerful strength. I struggled, blindly, grasping for something to ground me. But there was only the twisting blurring movement of the stars shining brighter and brighter, until they filled my entire field of vision.

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I jolted awake, head hitting the table. Tenderly my hand pressed against the injury, feeling what would surely be a raised bump by tomorrow. I put my glasses back on.

The dream again. The. Dream. Again.

Over the last few weeks, as my doctoral dissertation deadline grew closer and closer, the dream had come to haunt me whenever I managed to close my eyes and snatch a little sleep. But as my research floundered, the dreamscape was getting more and more ridiculous, evermore far-fetched. A young man. An older man. A beach…

There were pages and pages in front of me. Scrawled numbers cascading down each sheet. The lights in the rest of the lab had long since been turned off and the drafts cast across the table were lit only by my solitary desk lamp, the bulb as bright as the dream sun before the eclipse.

I sighed. Something had been eating away at me over the last few months, and every time I compiled new data that something got a little bigger and a little stronger, even though it had as yet refused to take clear shape. I sat back in my chair and rubbed my eyes. The scrawls turned into black ink swirls that burnt my vision, yet they also suggested something intensely important. Something just out of reach.

I glanced around the room. It was empty. Everyone else had gone home hours before, when the sun had begun to sink behind the rooftops of the Harvard College Observatory. Now, it was just me. And a long table. A weak circle of lamp light. The scattered notes. And a darkened room. Only the distant light of the night sky gave the air a subtle, silvery edge, with the nearest window showing an unreachable square of stars, outlined by a wooden frame.

***

I remembered the first time I saw the stars. Not the stars as we all know them. Scattered above us like hopeful stories, wrapped in the myths of fate and future. Not those stars which, beautiful as they are, have been there since the first time I ever looked up at the sky, as a trusting child.

I remember the first time I really saw the stars; seeing them as spectral phenomena that exceeded the familiar swathe, intense pricks of light in the dark cloth of the ancient sky.

This astronomical sky is my dream. It's what I dream about all the time. And all because of one day.

When I was nineteen, in my first year on scholarship at Cambridge University, I went to a lecture by Arthur Eddington, the renowned British astronomer. My own studies at the time focused on physics and chemistry and the lecture took my fancy because Eddington was to talk about Einstein's theory of General Relativity, in the light of his 1919 exhibition to the Island of Principe in the Gulf of Guinea. He had been observing stars near a solar eclipse, measuring

the gravitational deflection of starlight as it passed near the sun, testing, finally, the theory that Einstein had put forwards years before; that starlight will deflect when passing by an object as large as the sun. That light is affected by everything around it, that it moves, and responds, and reacts to objects that interrupt its path.

I sat in the lecture hall, crammed amongst the men. The smell of tobacco rose from their coats. Sweet. Acrid. A fug of masculinity. The men were variously tall or short or middling. Their hair straight or curly or non-descript. But as my fellow students they were collectively distinguished by a shared air of confident authority, and in the rarefied environment of the male academy I felt myself viewed somewhat askance. As a woman, as an alien creature from another planet. But I knew I was their equal. A star student who occupied her rightful place. So let them study me as they wished, these men. My mind would always be more than merely met the eye.

As I waited for Eddington's lecture to begin, I recall feeling comfortable, rather than uneasy in this space. For I thought I already knew what he would say, the famous man, since the subject of relativity was not new to me. In listening to the speaker, I was simply planning to enjoy a few pleasant hours of mental stimulation. Nothing more.

And then

he showed the photographs.

During a solar eclipse in 1919, as part of their data gathering, Eddington and his team had photographed stars on the Portuguese island Principe, off the coast of west Africa. When I saw these images, my body exploded. It was if I was seeing the sky for the first time. Experiencing the sky through the visibly disrupted relation of celestial bodies. Sun. Moon. Stars. My eyes. Had I ever even seen the simple sky before? Such spheres of dark and brightness. The flashes,

and the white intensity…In truth, I felt myself to be undergoing the sensation of a nervous breakdown. The photographs changed everything. They forever shifted the way I looked at the sky, its possibilities endlessly expanding through the illuminated radiance of particles into an infinite dimension in which all manner of matter and direction were tantalisingly revealed to me. In Eddington's lecture, forget men and women, I felt the distant identities of elemental geometries draw suddenly close, and then elusively recede. I was left longing to know the stars for what they actually were.

Untitled Project Draft

Testing the application of Meghnad Saha's ionisation theory in classing stars by their temperature. I propose that by looking at the wavelengths emitted or absorbed by stars it is possible to see what elements make up each star. Furthermore, I intend to prove that the variation in stars' stellar absorption lines is due not merely to the elements that make up the stars, but also to the different types of ionisation that occur at the different temperatures at which stars exist.

There it was. My premise. It was all there. Surely nothing more needed to be said. Yet in my early knowing, knowledge seemed to be a terrible thing, leading to unbearable heights of isolation. Where would my conclusions lead?

"Cecilia?" Dr Sheridan's voice echoed in the empty room.

I pushed my glasses up. Moved the spread of papers into a neater stack. "Do you need my help with something?" I asked my mentor.

"Not at all." He pulled a chair up to my desk. "And how is the study coming along?"

"Much of the same," I replied, putting the cap back on my pen.

"So, the conclusions are as we had hoped?" His eyebrows were raised in question. His weathered forehead gave way to a receding hairline.

"Yes, just as expected. The Sun's spectrum contains many of the same elements that we see in Earth's: silicon, carbon, other common metals. Which, of course, suggests the Earth is of similar elemental composition to the stars. But…" I paused.

"Is there something else, Cecilia?".

"Well, yes. The thing that has been bothering me, it has to do with the levels of hydrogen that have been showing up in the samples."

"Hydrogen?" He rubbed the bridge of his nose, "So, in your view, what does this mean?"

"I'm not sure yet. Perhaps it's only inconsistencies."

And then I went silent, knowing that what I wanted to say could change everything. *Would* change everything. Our understanding of the universe.

I studied Dr Sheridan's face, remembering how he and Professor Shapley had been so welcoming. How they had persuaded me to pursue the research I was currently working on, how they had never made me feel inferior just because I was a woman. They simply upheld the procedural truth of the science. And yet I realised that it was not the right time to propose something quite so big. First, I needed the proof to back up my claims.

***

My heart was racing. I knew what

it

was.

I had figured out what the numbers meant. The answer had been there the whole time, but I had not wanted to see it. I was unsettled. And with reason. Because if I was right, then everything would change. Well, maybe not *everything*, but a lot of things. My entire paper, for example. The fundamental premise and conclusion. If I was right, and if my paper was published, this would be a peculiar situation: a step forward for my lab but almost a necessary step backwards for physics, or at least a step in a very different direction from the established scientific path.

I had to be right.

Was I right?

Dr Sheridan would need to verify my results.

I needed another pair of eyes to reassure me

that mine were not mistaken

in showing me a crazy, radical truth.

Maybe I had just been staring so long at the sky

and at the confounding lists of numbers

that the vastness of the universe had finally made me crazy.

The old *luna*cy of the moon.

But I had been looking past the moon, past the stars even,

into the vibrant darkness.

“These are the results?" Dr Sheridan’s question was slow, muted. His voice shook slightly.

I nodded, nervously, turning over the next page and showing him another stream of numbers. Calculations that proved my point. Yet my hands were shaking.

“No *Cecilia*! You are telling me that your research, every single test, every calculation, leads you to imagine that stars are not as we have always believed?”

“Yes.”

He stared at me. I could not decipher the look.

“Professor, science has considered the stars to be merely planets, in composition. In essence, yes, the sun is not elementally different from Earth. But, look at the readings. The levels of hydrogen and helium are much higher in stars than we could ever had imagined. In fact, hydrogen is higher everywhere. It seems to be everywhere, making up everything.”

“You are saying…are you saying…that the stars are completely different? But it has always been known that they are the same, stars, planets, our Earth; they are made of the same stuff.”

“I know what has been *thought*, but take a look.”

His fingers ran over the pages, trying rapidly to process the findings. His eyes did not leave the papers in front of him. They were scanning, to and fro, as though hoping to discover a solid surface that would return the world to how it had been, the reassuring certainties of but a few minutes before.

A minor slip in detail would do it; give him the comfort of the old, established view of the universe. I could have made a mistake. Couldn’t I? I must have, surely. He was thinking that an easy comma out of place among the figures, a numerical code slightly mis-labelled, a calculation off to the smallest degree…any of these student errors he could circle in pen and

send me back to the desk, with encouraging words. I could almost hear them: *A fine job Cecilia. Very fine. But you must pay more attention to the minutiae. It is all very well to look for the bigger picture, but you cannot let the small things slip through your fingers.* He was always on the lookout for the devil in the details, it was what made him a good teacher. He let you explore on your own but would steer you back on track before you found yourself believing that you had solved the mysteries of the universe. Because who could do that, really? Only the Einsteins of the world.

Except that, this time, my old mentor could find nothing wrong. There was nothing amiss in a paper that had thrown his science into disarray. He was agitated. Seemed to have lost his own sense of calm direction and teacherly authority. He started to say something, but then stopped, unable to find the words.

I tentatively spoke. “So…if I’m right, and Dr Sheridan, I believe that I am, then every star is made up of a massive amount of hydrogen. An unprecedented amount of hydrogen. The implications of this for the greater makeup of the universe as whole would be …”

“Unparalleled,” Dr Sheridan murmured. His eyes were unfocused. His mind evidently hurtling. I smiled inwardly, recognising where I had been just the day before. Suddenly, he looked up from the pages, his eyes glossy and wide, and stared straight at me.

“Cecilia,” he urged, his voice breaking oddly, as though there was something caught in his throat, “You realise what this means, for us to publish this? For *you* to publish this?”

“Yes,” I said. A simple word, though my heart was beating so loudly I was sure that he must be able to hear it from across the table. My heart my mind my ideas my dreams…I felt as though I had dispersed into elements that were filling the room.

"Stellar Atmospheres; a Contribution to the Observational Study of High Temperature in the Reversing Layers of Stars.”

Testing the application of Meghnad Saha's ionisation theory in classing stars by their temperature, ~~I propose that by looking at the~~ this paper shows that by studying the wavelengths emitted or absorbed by stars it is possible to see what elements make up each star. ~~Furthermore, I intend to prove that the variation in stars stellar absorption lines is not just due to the elements that make up the stars, but also due to the different types of ionisation that occurs at the different temperatures that stars exist at.~~ Furthermore, the results of this research show that stars differ in composition to planets. Although these results differ from those which have been previously established, with stars heretofore sharing the same chemical composition as planets, this paper will show undeniably that stars consist largely of hydrogen. This finding reveals significant unknown possibilities about the composition of the greater universe at large.

***

My hand rested against the door, hesitant to knock. It was not often that Dr Sheridan called me to his office without a scheduled appointment. He had left a note for me in the lab, and his words had seemed uncharacteristically rushed, which had put me in a mood of unusual worry. Something to do with my publication, probably, since I knew that my paper had by now reached several scholars prominent in the field, and that not all the reactions would be good. Of course not! A young researcher, a mere woman, challenging the fundamental knowledge of an influential scientific field! But I was hoping, perhaps naively, that fellow researchers would be inclined to see the incredible science of it all; science as it should be seen, the search for knowledge, regardless of who makes the discovery.

The door swung inwards before I could knock. In the doorway, backlit by the gaslight, was my old professor. His normally upright figure was stooped, his thin hair awry. It was almost uncomfortable to see him in a such a state, without a jacket and with his spectacles noticeably askew.

"Excuse me, Professor." I backed up a step or two. "I understood that you had sent for me? If this is a bad time I can always return later."

"Not at all, Cecilia," he said, sighing, attempting to straighten his dishevelled hair. "Come in. I'm afraid I have some unfortunate news."

***

His study was a small room, lined with dark wooden bookcases filled with even darker volumes, bound in black and navy, brown and deep green. Darkness made the room seem smaller than it was. A large desk threatened to overwhelm the space further, and the lamp flickered, sending shadows of pens and paper stacks wavering across the bookshelves. Professor Sheridan ushered me into one of the embroidered chairs facing his desk, one of those seats that look comfortable yet are anything but. He took his time to settle behind the desk, tidying papers and clearing his throat multiple times. The silence in the room became more and more unbearable.

"Professor -" But he waved his hand to stop me.

"Miss Payne," he said, "my dear *Cecilia*. I cannot pretend that we should be surprised. There has not been the best reception of your paper."

"Well," I let out a breath I had not known I was holding. "Yet there might also be some good in the reviews?"

"Unfortunately, there is not. His fingers agitated the stack of notes on his desk. He could not meet my eyes. "I think, and I am so sorry to say this, but it seems we might be best obliged to do some, some, as they say…damage control."

His words hung in the air like the unruly particulate dust of some galactic explosion, like when sunlight comes through a window and you can see the swirling motes suspended in the air.

"What?" I said. Abruptly aware of my rudeness.

"He stuttered. "A a a I am so sorry …"

"Just say it, Professor!"

"I think we must shift the, the, the tone of your paper," he finally said, "the odd phrase. We must adjust the paper to make it a little less aggressively against that which the men out there believe to be true."

I felt myself plunge into a disorientating vortex. "*Why*? *How*? Surely it is obvious that if I recast my research to support what they believe then I must undermine the entire thesis of my paper!"

"No, no, you misunderstand. A a few words. And the, the…simply make it so that your research is less of a *conclusion* and more of a suggestion. A speculation, shall we say?"

"That is preposterous! Then why publish the findings at all?"

"Because your ideas will at least be in circulation, Cecilia. They will be out there, in the known universe, until they find traction. Is that not better than nothing?"

"But Professor! My conclusion is proven! It is a fact that I have proven. Why should I hide the truth?"

Dr Sheridan closed his eyes, his jaw tightening.

"Cecilia. *Miss Payne*," he spoke quietly, but emphatically. "I believe you intelligent enough to know the answer."

"Stellar Atmospheres; a Contribution to the Observational Study of High Temperature in the Reversing Layers of Stars."

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YOU HAVE ARRIVED

Gladys West

[i] Loading . . .

February 1946

You are 'HOME' ❍ Sutherland, Virginia

Weather ☁

▸ Enter destination _ _ _ _

❍ OUT

ERROR Route not possible.

Beyond the window of her parents' small house, tobacco fields stretched further than she could see. Rows of green sunbaked plants and brown earth that seemed to insist, over and over: *stuck here, stuck here, stuck here.* The leafy, earthy smell stuck to everyone's skin. It lingered on her mother clothes when she returned from the factory in the evenings; it lingered in the creases of her father's field-worn hands, even on the days that he worked at the railway. It was in her sister's hair when they slept together on their small bed. And she knew, though she could not smell it because of that strange way that you cannot smell yourself, that she too must be carrying that smell in her bones. It had become a part of her. Tobacco, corn, cotton. Mainly, black lives picked the crops or worked the factory, thrashing the tobacco leaves into shreds.

But she was not going to be stuck here, Gladys told herself. She was going to pull her feet out of the soil and shake them off and move forward, somewhere else. College. That would be her ticket out.

Gladys left the window and returned to her schoolbooks, neatly spread out across the bed. She began, once again, to pencil in numbers in neat rows. She added them, subtracted them, scratched out those that did not work. And all the time she heard the tobacco plants and the dirt clods, the whispering little breezes that ran through the rows. S*tuck. Here.*

May 1948

▸ Enter destination _ _ _ _

❍ Virginia State College

i Calculating Route . . .

"And our Valedictorian for the class of 1948 is …" the principal announced to the seated crowd, crushed in the wood-panelled hall. Gladys gripped her thigh tightly, trying to stop her leg from bouncing up and down. The room was stuffy and hot. Her dress was sticking to her back.

"Gladys Mae Brown!" The room burst into applause.

Gladys stood slowly. Legs shaking. Moved awkwardly through the space between chairs and legs, the room swaying. She had done it. She could not quite believe it but here she was walking towards the front. Here she was accepting a piece of paper from Mr Underwood. Here she was turning towards the crowd, the lines of people, the rows of faces. All looking at her.

"As you know, as the valedictorian, Gladys will receive a full scholarship to Virginia State College to study a course of her choosing." The Principal beamed. "Gladys, we look forward to discovering your future success!"

"Do you know what you're going to study?" Gladys's friend asked, as they stood outside after the ceremony. Other students surrounded them, and occasionally patted her on the arm or the

shoulder in congratulations as they passed. Gladys's fingers still tightly gripped the certificate, as though it might otherwise disappear and, with it, everything it promised.

"What are you going to study?" Her friend asked again, "With your grades you could choose whatever you like. History or English, I bet? Teaching?"

"I was thinking science or mathematics."

"Math? You sure? That's a hard one."

"I've done pretty well in it so far," she shrugged, waving the certificate a little.

"Yeah, but this is high school, Gladys, college is another story. Rather do something nice, something certain, since you have the chance to go."

Gladys nodded, though hardly listening. The sounds around her had begun to fade. Not because of the shaking, or the empty disbelief of before. This time the sound cut off sharply, with the clarity of what lay ahead.

▸ Drive straight for 500 m

"Okay class, my name is Miss Brown, and I will be teaching you math this year." Gladys pushed back her shoulders and let out a deep breath. The busy classroom slowly quieted down. "We start with fractions."

She turned to the blackboard and began. Tiny plumes of chalk dust drifted down and powdered her shoes.

½ ⅓ ¼ ¾

Soon, her students' heads were bent over their desks, pencils scratching against paper. She settled down to grade answers. In front of her on the desk, in view every time she looked up,

was her college graduation photo. She looked at her smile, frozen forever in happiness. A surreal moment. And yet she missed that feeling already. She had debated with herself: study further or stop; but after four successful years this teaching job had seemed the best option. A salary. A chance to rise in the ranks. Social security. She kept marking; her eyes drawn back to the photograph. Maybe in a few years…

▸ Make a U-Turn at the next opportunity

"Miss Brown! *Hello*! I see you are back."

Gladys turned to see her favourite professor walking up the corridor.

"Yes, I decided. I must continue. Get my Masters."

"Well, I am glad to hear that," the Professor said, shaking her hand firmly. "You were a very talented student, particularly with your, well, your disadvantage."

"Sir?"

The Professor hesitated, suddenly awkward "A lot of women struggle in the subjects that you chose."

Gladys felt her heart lurch into her throat. She swallowed the visceral rush of déjà vu, remembering her first year at this university. "Well, I didn't struggle, if I am honest, sir."

"Mmmm," the Professor mumbled, "Yes. I hope you go the distance, Miss Brown! I'm sure that you'll be fine."

He turned on his heel, footsteps echoing loudly on the wooden floor. The familiar corridor felt cold, and empty. Unwelcoming.

▸ Turn right and continue straight

"Miss Brown recently graduated with her Masters in Mathematics from Virginia State College, so we are very happy to have her teaching with us this year." The principal smiled in Gladys's direction. The class looked bored. "Won't you welcome Miss Brown?"

There was a murmured chorus of generic welcomes. The children shuffled. Gladys studied their little faces. The boy with his shirt collar turned inside out. The girl with smudges all over her glasses. Another with her eyes resolutely on the ceiling. No one ever liked taking math in school. But she hoped to find at least one child like herself, who would thrill at the beauty of numbers. And all of the kids, really: she loved to see their faces when they discovered how the right equation, with the right numbers, the right symbols, and the right calculations…all those confusing numbers stopped spinning just long enough to hold together just right, creating something new.

The room was already filling with the noise that only a class full of middle-schoolers could create from nothing. The principal bent to Gladys and whispered, "Okay, I'm going to leave them in your very capable hands!" And she slipped out of the door. The noise escalated. Kids shouting names. Kids laughing. Some boy tugged the braids of a girl who was talking loudly to her friend. Then there was angry shrieking, and boys guffawing.

"So," Gladys addressed her rowdy class. "Who can tell me how fractions work?"

Sudden silence. Nothing shut children up like mathematics.

1956

i Recalculating . . .

▸ New destination _ _ _

❍ Naval Proving Ground, Dahlgren, Virginia

"Welcome to the Naval Proving Ground, Miss Brown." The officer said, handing Gladys an identification badge, her name in small black letters. "Happy to have you on board." She found herself steered deftly along a series of bland corridors punctuated with offices. Many doors. Labelled with numbers and names that blurred, given the speed at which the officer and Gladys were striding.

"We are very proud of the work that we are doing here, Miss Brown. I hope that you will soon find your place."

"I'm sure I will, sir."

Yet she did wonder, for a moment, what she was doing at a US Navy base. Why she'd responded to the call. This wasn't an environment she'd imagined working in. Wait up a bit, she told herself. Wait and see. Perhaps if she could generate accurate data, carefully figuring the necessary calculations, maybe that kind of work could help to make the world a better place? Her mind whirled, computing the possibilities. Just maybe, she thought, this is where my life as a scientist could really start?

Her guide suddenly stopped at one of the many doors and pushed it open, leaving the door for Gladys to catch as she slipped in after him. A handful of men grouped around a long table surrounded by chairs. Men holding mugs of coffee, or sheaves of paper. Talking, drinking, putting off the moment that the real work had to begin.

The officer waved a hand around the room, pointing out the members of the team. Gladys followed his hand, trying to memorise names, faces. One man met her eyes with a fiery intensity.

"Ira West." Mr Johnson said. "A mathematician like yourself."

"How are you, ma'am?" Ira West nodded his head politely.

"Excited to be here," Gladys felt a flush in her cheeks.

"I think we're all very happy to have someone like you join our team."

"Someone…like…me?"

"A woman! I guess a woman must have quite a brain on her, to be working here."

"Well, I guess I must presume the same about you, Mr West. For a man."

▸ The Chapel is on the right.

They stood outside the chapel. All around them were friends and family, flitting, floating between groups, joining in hugs and congratulations.

"Well, Mrs West," Ira whispered, "what do you want to do now?"

"I don't know." Gladys linked her arm through his "Maybe get another degree?"

Ira laughed. A laugh that took up his entire face. Full of joy.

"Can that possibly wait until tomorrow?" he asked, her hands held in his.

"Maybe," she joked. "But you know, I think I might just do it."

"Whatever you want, my love." He kissed her cheek.

▸ Please note you are reaching the speed limit

1975

i System updating . . .

▸ New route found _ _ _

i Recalculating . . .

The room was hot. The wall of machines blinked and hummed, whirring under the fluorescent lights. Yet under the noise was an eerie silence. In the middle of the room: four people. Gladys and Ira; their coworkers James and Godfrey. The chairs clustered around Gladys's desk, which

was stacked with papers and books. The team watched as their leader consulted a thick file, as her hands systematically entered commands into the IBM computer.

"You sure?" Ira asked. Gladys only nodded.

Data readouts spluttered out of the machine and the researchers rushed to compare numbers with other numbers. Measurements with other measurements. The Seasat project, a satellite rotating hundreds of miles above their heads, was beaming back data into their lab. For the first time it was possible to see not just the land, but the oceans as well. The winds across the seas, the heights of waves in the deep empty areas of the ocean, the ice caps - all of it was being reconfigured as data, and relayed. Gladys knew that if they took all of this, all of the information, then they could construct a data image of the planet. They could map the Earth, not just as a flat thing with the shapes of continents and countries and islands, but a perfect mathematical construct of the ever moving, ever changing spherical Earth.

"I think we might have it." Godfrey spoke softly, glancing at the notes spread across the table.

Gladys nodded, though distracted, quickly sketching an unbalanced circle on a scrap of paper. Not a perfect sphere, but slightly squashed at each end, rather like an orange. If she closed her eyes, in the empty curves of the rough drawing she could see the ocean waves as the tidal variations pulled the coastlines. She could see the invisible gravitational arcs as they moulded and changed the sphere's edges. She could see, somewhere, around the pen lines on the page, the tiny satellites as they caught every motion, every indiscernible crevice and bump and slope and peak. Gladys smiled to herself.

When she looked up, the numbers on the screen in front of her were blinking green: *you are here, you are here, you are here*, they seemed to say. At last.

❍ You have reached your destination

2018

You are 'HOME' ❍ Virginia

Weather ☼

Lieutenant General David Thompson stood straight and proud, behind him the blue flags emblazoned with the Air Force Space Command emblem. Beside his towering figure Gladys seemed small. She was overwhelmed by the moving mass of press and cameras; the flashes and the faces that filled the room. As though from a distance she heard the Lieutenant speak. His voice crackled through the interference of many microphones. Static zinged around the room. Gladys could barely hear his words. He held out a small plaque. She grasped it in tiny hands. This all seemed so strange. She had been happily retired for many years. No one knew her name. And now the Hall of Fame? For her?

The journalists were crowding around her, large microphones pressing closer and closer, the way clouds cluster around mountains. Or how waves move closer and closer to the shore with the incoming tide.

"Mrs West, what are you going to do now? Do you have any plans?"

Now? She wondered. She had not worked in many years but something missing had always hung around her. That pesky PhD.

"You know," Gladys said finally, "I think maybe it's time to get another degree?"

▸ Enter destination _ _ _ _

❍ Virginia Tech, Virginia

i Calculating Route . . .

Fossilised
Mary Anning

Crack.

Mary watched as her brother tapped a rock sharply with hammer. The rock cracked down the middle. Mary held one side; her brother held the other and carefully they prised the halves apart. Within the grey, a strange shape. About the size of Mary's palm, shiny. Almost as though made of the stone itself; to the untrained eye, just another part of the rock. Maybe a mineral growth. A conglomerate. A rock within a rock?

"Woman is utterly unable to compete with man." (J. McGrigor Allan, anthropologist 1869)

But Mary recognized it. An ammonite. An ancient creature of the sea, long extinct. Ammonites were once living creatures that floated through the oceans, ancient relatives of modern squid. But now all that remained were these strange ridged whorls and stony frills, rock-like remains hidden within bigger rocks. Washed up on beaches, dug out of cliffs.

"Women are marked out by Nature for very offices in life than those of men, and that the healthy performance of her special functions renders it improbable she will succeed, and unwise for her to persevere, in running over the same course at the same pace with him. For such a race is certainly weighted unfairly." (Henry Maudsley, M. D. 1874)

"It's a beauty," Mary's brother said, as they carefully chipped the rock around it away, leaving just the thing behind.

Mary cradled the ammonite in her hands. It was heavy, dense, the ridged edges smoothed by time. Grey light filtered through the clouds; caught the hidden grooves. Every

"The dangers of overeducating women; they could develop 'anorexia scholastica' making them immoral, insane, and asexual." (paraphrasing of William Withers Moore, President of the British Medical Association, 1886)

time she held one, she remembered the first time. Her father had placed a heavy rock into her hands and explained to her that it was from a time *before.* A time before humans, before houses, and before God. He said that these rocks showed us that the world is older than we could ever know, that there once were that walked the fields and roads that were not there yet. Before our time. She was holding proof of that.

"Let's move up the beach," she said, wrapping the ammonite in a cloth and packing it carefully into a basket. "We've had a good day so far. I feel we might find something special today."

"Well, as long as it keeps the food on the table," her brother quipped, and together they hauled the basket further down the sand, clambering over rocky stretches. Along the way to the cliff face they stopped a few times, seeking out rocks that had tumbled from the sheer heights above. As the waves pulled these rocks out towards the ocean, and then hurled them back again onto the shore, the stone was broken up and strewn across the beach in scattered piles. Sometimes they would find, just beneath their feet, the exposed shell of some creature from the long gone past, right there where they now stood.

"It is not that girls have not ambition, nor that they fail generally to run the intellectual race which is set before them, but it is asserted that they do it at a cost to their strength and health which entails life-long suffering, and even incapacitates them for the adequate performance of the natural functions of their sex."
(Henry Maudsley, M. D. 1874)

"There are a large number of women whose brains are closer in size to those of gorillas than to the most developed male brains … the inferiority is so obvious that no one can contest it for a moment."
(Gustave Le Bon, French Polymath 1879)

"There are differences between the intellects of men and women, and … these are best understood by a study of the differences in their bodies."
(Sir James Chrichton-Browne, M. D. 1892)

They looked out for tumbled rocks dislodged by the tide. Rocks with a fine crack around the entire perimeter. A natural equator line, waiting to spilt the world in half. Nested inside was almost always a beautiful specimen, in the gap. A few taps from a small hammer and the rock would split. Inside: some hidden treasure. Snake stones. Devil's fingers. Thunder stones. And their proper names? The strange italicized words from the library books. *Ammonite*. *Belemnite. Plesiosaurus.*

"The relatively few women who are in the highest ranking places are disproportionately either unmarried or without children … And it is a fact about our society that [a high powered profession] is a level of commitment that a much higher fraction of married men have been historically prepared to make than that of married women."
(Dr Lawrence Summers, President of Harvard University, 2005)

Mysterious words conjuring creatures and things buried deep below the surface of everyday society. Everywhere people walked, living their patterned lives, below their feet might lie some fossilised thing.

Something so old and bizarre you would believe it couldn't possibly ever have existed.

"The distribution of preferences and abilities of men and women differ in part due to biological causes and … these differences may explain why we don't see equal representation of women in tech and leadership."
(James Damore, Software Engineer at Google, 2017)

Afforestation

Wangari Maathai

We

were trying

to replicate

what we had seen

in the West, across the waters,

the world we saw

on televisions, in newspapers,

to live the same lives as those other people

the ones that were *developed*.

We wanted the same things that they had, at any cost,

to catch up to where they said we were supposed to be.

But, when we did

we destroyed

we cut

we burnt

we detached

ourselves

from nature

we lost and

we became lost

I tried

to preach

the green gospel

to use my hands to rebuild

what other hands had torn down

I tried to ask for a shift in thinking, our thinking,

I told them we are tearing apart our life support system

we cannot heal our wounds without healing *hers*.

We have forgotten

that

we are

part of

a larger

family

of all

the life

on earth

But when

I spoke to them

to the people who did not see

who saw the forest's flattening as part of it

not us, the development, that we *needed*,

they told us to sit down or

they would fell us

like

the

trees

Inside Us

Rosalind Franklin

What do you want to be when you grow up?

Rosalind hated this question more than any other. Her aunt was looking at her expectantly across the table. Ros glanced at her mother who gave her a small smile, not willing to meet her gaze. Her father, at the end of the table, had paused, his fork suspended between plate and mouth, a piece of potato hanging precariously. He met her gaze firmly, his mouth set in a straight line. That line said it all: leave this alone.

"I want to be a scientist," she blurted.

"Oh, how wonderful," her aunt cooed, and touched her arm fondly, "Wouldn't it be lovely to have a scientist in the family?"

"I'm sure that she would do very  [1]well," her mother murmured, matching her sister's smile. But Rosalind could feel her body tensing in the chair beside her. There was a pause.

"She should really go to St Paul's, shouldn't she then?" Her aunt continued, oblivious to the tension that had descended on the table like a pall, "I hear it's the best school for girls, in terms of science. She would have a real shot of getting into Cambridge from there."

Rosalind's father cleared his throat. Rosalind stared at her plate and began to eat her vegetables in earnest. As though filling her mouth might somehow close his.

"Rosalind *will* be attending St Paul's," he said slowly, his voice descending on the table like a storm cloud, "But not to pursue this silly science dream. And I will not have both of you pandering to her ridiculous fantasy."

---

[1] Figure 1

"Ellis. *Darling*." But he silenced his wife with barely a glance.

"I am serious, Muriel, I don't want to hear it!" He slammed down his fork. Rosalind watched as the potato that had been clinging to the tines went flying onto the lapel of his suit jacket. "And Helen," he fired his gaze at her aunt, "Don't you come in here and give her all these ideas. She will have a respectable career. She will learn languages and music like any respectable woman."

"Will you look at yourself, Ellis?" Helen shot back, placing her own fork down silently. "Ros is exceptional, anyone can see it. Her schoolwork is impeccable; she wins all of those awards; she does the arithmetic for fun. Ros is miles ahead of the other girls in mathematics, why not allow her to do what she is good at and what she enjoys?"

She cast a quick, encouraging glance at Rosalind.

"I won't hear of it, Helen!" He all but shouted, before reigning himself in. Took a large breath. A larger gulp of wine. "She will take my advice and pursue the arts. Perhaps she should strive for some awards in music, languages, since I have yet to see any success there. This mathematics obsession? A fantasy. A phase. Believe you me, no woman will take any real joy from figures later in life. And besides, what man would want her? A scientist, hmpf! In some stuffy, dirty laboratory somewhere, surrounded by other men. It is degrading. And it is completely unsuitable for any daughter of mine."

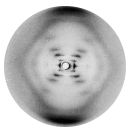
With that he stomped from the room with his wine glass. On his collar, the small lump of potato that would not dislodge. Under the table Rosalind's mother squeezed her daughter's hand.

****

"Please come back inside, Miss Franklin."

An elderly professor stuck his head out from behind the door to Rosalind's left, and she stood up from the wooden bench she had been awkwardly perched upon for some time. Re-entering the panelled room she once again faced a collection of senior gentlemen who were seated behind a long wooden desk. This solemn, scholarly row was backlit by a large window, creating strange shadowy figures out of the men, their glasses blindly glinting.

"Please, take a seat," said the man who had ushered her inside. He gestured to the single wooden chair across from them, placed in the centre of the room. She walked over and sat, then blinking in the white glare from the window.

"Thank you for joining us again," the man in the middle said, glancing up and down the line of men in front of her,  "After considering your presentation based on your work with the British Coal Utilisation Research Association during the war, and your investigations into the properties of coal and graphite: Miss Franklin, we have decided to grant you a doctorate in physics. Congratulations!"

"Thank you, Professors! I am truly grateful for the recognition."

"You have done the institution of Cambridge proud, particularly following such a devastating war. We look forward to seeing where you go next with your research."

"Do you have a subsequent course of employment, or research, Dr Franklin?'

It took Rosalind a second to process the question, the word *doctor* shining above her head.

"Doctor?"

"Yes, sorry Professors," she gathered her thoughts quickly, "I have been offered an appointment at the Laboratorie Centrale des Services Chimiques de l'Etat."

"France?" One of the men observed.

"Yes, in Paris. I studied French in France before I came to Cambridge, so I have friends there. They are starting new work on X-ray crystallography, and I hope to bring back the information to England in a few years."

"Crystallography? Fascinating"

"No doubt we will see you again on your return."

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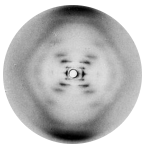
"Professor Wilkins, I presume," Rosalind extended her hand towards the spectacled man. Professor Maurice Wilkins stood unmoved, arms firmly crossed over his chest. After a while of silence Rosalind dropped her hand.



"I am Rosalind Franklin?" she said awkwardly, "I was asked to come here to assist you in upgrading the lab."

"I told the board that I do not require your help in this regard, Miss Franklin," Wilkins was curt.

"Dr Franklin," Rosalind corrected him, "And actually, I believe that you need my help. The laboratory needs to be upgraded in order to …"

"My laboratory works perfectly fine, Doctor."

"Not for the Institute's proposed work on discovering the shape of DNA!" Rosalind felt impatient. "And I believe you were informed of all this. If we want to advance these upgrades are crucial. May I say that I have worked for the last *four* years in Paris and the French team made significant progress, but with *your* lab as it is, the British might as well throw their project away."

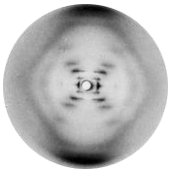
Professor Wilkins looked disgruntled. Rosalind sensed that if manners permitted him to spit on the ground in disgust, he would. Not a good start. It seemed her time here might not be as productive as she had hoped.

"Good Afternoon, Sir, may I assist you?" A tall man stuck out a hand towards the young man in his laboratory doorway.

"Yes, I believe so." The young man enthusiastically shook hands. "My name is Watson, James Watson. I spoke to Professor Bragg about joining your team."

"Ah, yes of course, Dr Watson," the taller man said warmly. "I am Dr Perultz, I heard that you would be arriving. Come on inside." He ushered Watson in.

From behind a long desk strewn with papers a gangly young man in scruffy clothes rose from his chair.



"Crick, this is James Watson. He's joining our team. Watson, this is Francis Crick. He is supposed to be writing a dissertation under me, if he could just solidify an idea." Dr Perutz's comment was jesting, rather than barbed, and he excused himself while the young scientists got acquainted.

"So, what is your supposed dissertation supposed to be on?" Watson asked. Crick sighed and sank back down into his chair.

"X-ray crystallography of haemoglobin. I think. I find the concept of the photography fascinating, I just haven't found *that thing* you know. When you just know that you need to work on something important, but it's still missing in action?"

"That's exactly why I'm here!" Watson replied, pulling out a seat opposite his new colleague, "I just happen to have found *that thing*. You ever heard of Dr Wilkins?"

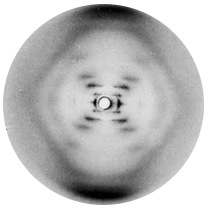
"Wilkins … over at King's College, right?"

"Yes, exactly. He's in the X-ray crystallography lab there; it was his idea actually, to start work on it. But anyway, I attended a lecture of his in Naples earlier this year, and he was talking about initiating investigations into the molecular structure of DNA."

"Ah, the big new DNA debate," Crick nodded.

"Mmm. He was talking about photographing DNA. As in, we could be close to figuring out the actual shape of DNA. That's why I'm here, I think we could crack it. Figure out what it looks like."

"We?"

"Well, I'm looking for  people to work with me. You interested?"

****

"Rosalind?" Dr Randall approached her desk, and rested both palms on the wood. He made for an intimidating figure in the small room and she looked up tentatively, almost expecting a tirade on how she and Wilkins needed to resolve their differences. However.

"I want you to move your research focus."

"Move it?"

"Not completely. But, I think that you should be looking into DNA fibres."

"But…fibres?"

"Yes, forget the initial research for now. Leave the X-ray diffractions of proteins and lipids. I've been talking and it seems that there is a lot to be done in this idea of DNA fibres."

"Fibres. An interesting idea, I suppose. It could be useful for figuring out the …"

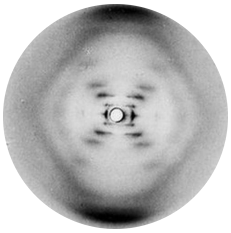
"…the shape of DNA, exactly. Yes. And to be honest, Rosalind," Randall said, leaning forward slightly with a sideward glance to the rest of the room, "You are the most experienced person here, in terms of experimental diffraction."

"Well," Rosalind paused awkwardly, not sure what to say, "I don't know if that's accurate. Dr Wilkins has…"

"Dr Wilkins is very accomplished," Randall interrupted, "But in this case, and don't tell him I said so, but in this case it's you who should be on this."

Rosalind let out a deep breath and leant backwards in her chair. She was relieved that none of the busy, bent heads in the lab was paying attention to the conversation.

"Well, thank you very much, John," she said, muting the excitement in her voice.



She tried to remain neutral, at all times, since the men in the laboratory seemed unnerved when she showed emotion. It was always 'too much'. Although, they seemed equally unnerved when she showed none at all. It appeared a woman could never win, in that department.

"Hey, smile won't you," Randall said, "I've just given you a great opportunity."

Rosalind feigned a small rictus across her face. Randall seemed to be satisfied and started to walk away. He paused after just a few steps.

"Ah, also: I am assigning you Raymond as your assistant on this project."

"Raymond? Gosling? Raymond who is currently Wilkins's assistant?"

"Yes, the very same."

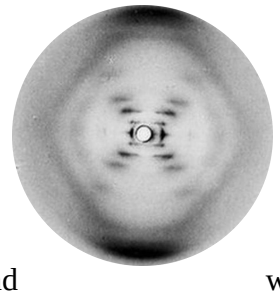
"Great," Rosalind said, through gritted teeth.

As if that won't cause even more problems.

****

"Hold it steady now, Gosling," Rosalind muttered, adjusting the equipment carefully. "This is photograph number one, please make a note."

"Very good." Gosling agreed, though he seemed distracted, glancing over his shoulder. The machine allowed them to suspend a strand of DNA, fixed to a support that they could then photograph. Over the last few weeks Gosling and Rosalind had figured out how to separate the DNA and pull it into minuscule strands which they could photograph. It had been difficult to do it properly at the beginning, though she'd had practice before, in Paris. The persistent problem was the scale on which they worked. To the naked eye the DNA was not even visible, so they would be using X-rays to create a photograph from the invisible thing. The X-rays would bounce off the electrons inside the atoms inside the molecules, scattering in patterns which might eventually form a blurry black and white image. Every time they attempted a photograph, she knew why she enjoyed her work so much. With every photograph, those invisible X-rays would bounce across invisible particles crossing invisible boundaries and somehow forming a visible image of this tiny thing that seemed to make up everything that was human.



The strand of DNA was set into a tiny support, sealed into a camera. Behind it they had placed a piece of X-ray film. This film and the DNA would be exposed to X-rays for the next few days, and then they would develop the film and hope that the strand had not moved. If it moved, they would have to start from the beginning, hoping for a clearer image of this fundamentally improbable matter.

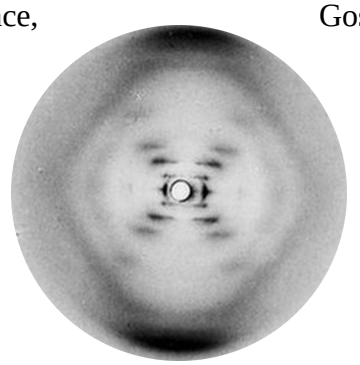
"It's secure, Dr Franklin." Raymond Gosling noted down the settings of the machine.

"Let's start this up then. X-ray diffraction photograph number one. Now, let's start the hydrogen," Rosalind said, and Gosling carefully turned on the machine. The hydrogen was bubbled through water into the camera itself, which would stop the X-rays from bouncing off of other molecules, in the air. This ingeniously focussed the rays, making sure that the end result showed only the shape of the DNA.

"And now, we leave it," Rosalind said quietly, taking a step back from the apparatus. She and Gosling stood together, taking a moment to watch the instrument do its work.

"We leave it, and hope," Gosling added.

"No, we do not hope in science, Gosling. We see what happens."



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James Watson was disgruntled. He was standing in front of a pile of metal sticks and Crick was sketching yet another diagram in his notebook. All of the pages in the notebook, and all of those pages torn out and thrown onto the desk, held similar sketches. Every new diagram had resulted in the building and tweaking of models to represent the rawing. Yet every new model had been found wanting. Something was wrong. Crick sighed and scratched out the new diagram. He must start over.

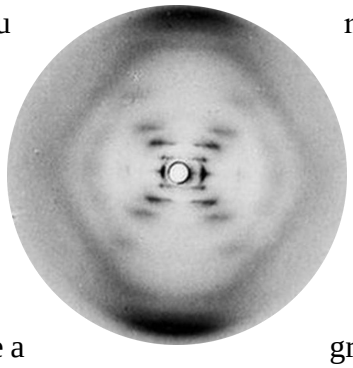
"Let's see the report again, the one from King's College?"

“We’ve read that report a hundred times, Crick,” Watson moaned, but dug around the papers and extracted the report that they had, well, let’s say, ‘acquired’, from Crick’s advisor Perutz. The report was meant for the Medical Research Council’s biophysics committee, and detailed the crystallographic calculations of the X-ray crystallography department at Kings College. Many by a woman named Rosalind Franklin.

“I know, but this is what we have James.” Crick started to flip through the paper. “This is the most recent work on the stuff. If we can just figure out what it translates to, physically, then this model could actually take shape.”

“Can you believe that they aren’t trying this over there?” Watson asked, playing with the pieces of metal scatted across the table.

“Building a model, you mean?” Crick replied.



“Yes, it seems so obvious, I think. To try and find the physical form of an object you should be working with physical things. Not to mention how much more impressive a photo it will make when you have a great big model of something. What is she going to pose with? An exciting stack of papers?”

“I’ve heard she refuses to work with models,” Crick said, his eyes still scanning a page of numbers. All over the sheet were pencil scrawls. Thwarted past attempts to see the figures in the real world.

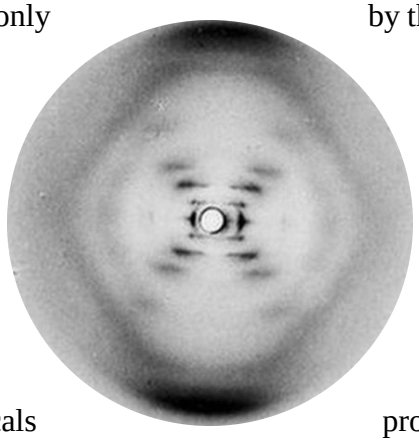
“How can scientist not work with models?” Watson asked, of no-one in particular, “It’s part of how we do things. What about Linus Pauling? He figured out what the alpha helix looks like thanks to models. Who does this woman think she is?”

"I think she just sees no point in building a model when there isn't enough information," Crick muttered, referring back to one of their previous attempts in the notebook. "And honestly, James, she might be right. *We* might be close but we're far from there yet. We don't have enough evidence to build anything with any certainty."

"We'll get there, Crick." Watson waved away his colleague's worries with the air of the self-assured. "I can feel it. We just need the last puzzle piece."

****

The darkroom was dark. Lit only by the red lamps in the corners, the room had become a comfort to Rosalind over the last few weeks. She had always enjoyed the process of developing film, particularly X-ray film. There was something about the way that the paper, when given the right bath in the right chemicals produced something from nothing. The beauty of X-ray photography was that you never knew quite what would appear. In hobby photography, you took photos of what you wanted to see again. It was a way to preserve a moment you never wanted to forget. But when she put the X-ray film into the developer she was always aware, always just a little bit excited, that what would develop might be something utterly new; something that had never been seen before. The process created the image of something that human eyes could not see, never mind understand, and yet scientists were completely reliant on this obscure process in order to complete the very action of making the sight possible.

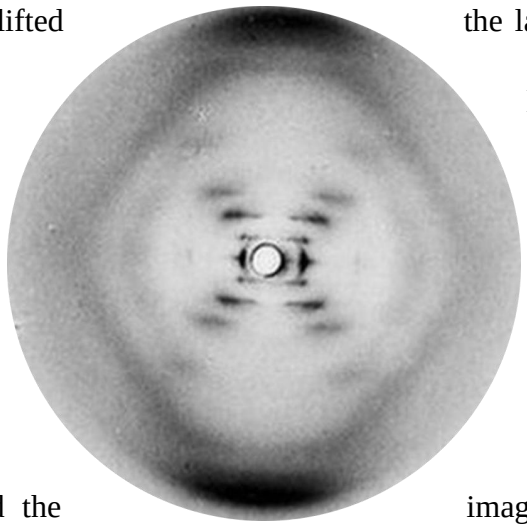


Gosling offered her the tongs, but Rosalind waved them away, gesturing for him to continue. She was feeling very uncomfortable. Physically. When bending over the chemical baths, she had felt as though her skirt was too tight, pressing and cutting deeply into her stomach. Straining to hang the last few photos had stretched her stomach awkwardly, and she found it better not to move.

"Everything alright?"

Rosalind noticed that her hand was pressed into her stomach. She quickly withdrew it and shrugged. "Of course, carry on."

Gosling carefully lifted the latest photograph from the chemicals with tongs, letting the excess liquid drip from the paper before dipping it into another bath to rinse it, and lifting it out once again. Rosalind took the paper from him and pegged it to the line suspended across the room. They both studied the image. Photograph 51.



It was hard to make out the details in the dim light, since the red bulbs turned all greys into one smudged mass on the page. But.

Something about this photo seemed different. Though the greys were blurred with the background, black lines stood out distinctly. More clearly than in any of the fifty images before it: two broken lines of black marks forming intersecting diagonals across a rough diamond shape on the paper. Gosling and Franklin stood unspeaking as the photograph developed. As

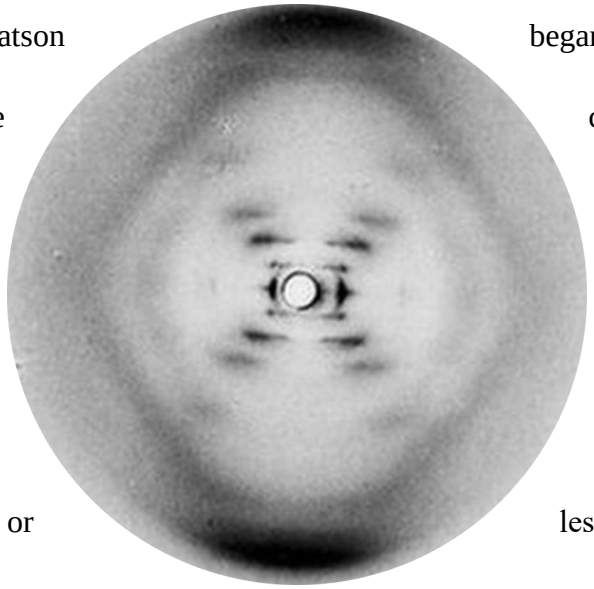
their eyes adjusted to the dark. As they realised that, maybe, they had just found it. The shape of DNA. The hidden form of what makes us human.

****

"Okay, okay wait," Watson cried, pushing his empty beer glass to the side of the small table. His elbows jutted into the neighbouring tables. The little pub was overflowing out on the street, everyone rushing and drinking and talking and meeting and forgetting the day behind them.

"Okay wait what?" Crick asked, after Watson had paused for a bit too long.

Watson scratched around in his jacket pocket for a pen. "Give me your napkin." Crick slid it across the table and Watson began to draw. He made a rough 'x' shape in the corner of the paper napkin.



"This is what we saw in the X-ray photograph right? The image that Franklin girl managed to get."

"Yes, more or less," Crick agreed, turning the napkin so that the x was horizontal. "If we consider that the DNA strand was stretched out like this, for the photograph to be taken, what does that say about the shape?"

"It looks symmetrical," Watson noted, and gestured for the notebook next to Crick's glass. He flipped through the pages, covered with the various renditions of their so far failed attempts to materialise the model of DNA.

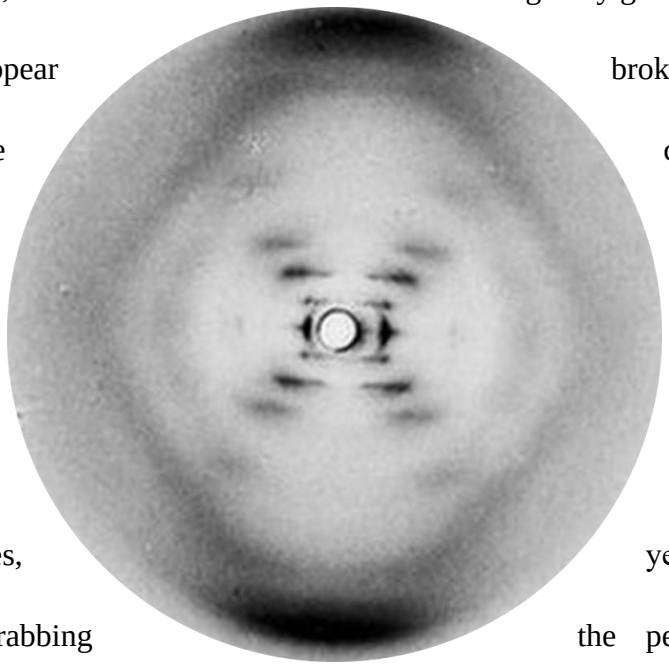
"Look, we've been working on the idea that there could be three helix's right, to human DNA."

"Well, that's what we all thought," Crick agreed.

"But," Watson said flipping through the notebook again. "We have also speculated that there are only two. And this photograph suggests we might have been right."

"It did look like two; crossing over like so." And Crick extended the single X by laying over it another X and another, creating a long winding string shape across the napkin.

"Exactly!" Watson cried, throwing out a hand and almost toppling the pint by his elbow. Crick grabbed the glass before it could smash. "…but wait, if we consider the calculations we've seen before, we could logically guess that these sections, where the lines appear broken up in the photograph, these could be the necleotides!"



"Like this?" Crick started to add small marks along the spiralling line.

"Yes, yes, yes!" shouted Watson enthusiastically, grabbing the pen from Crick to redraw the image, smoothing the lines; adding the marks for nucleotides. When the sketch was finished, both men sat back in their chairs and Watson let the pen drop to the table.

"Shit," Crick murmured, half under his breath, "I think we did it."

They sat in silence for a while, unsure of what they needed to do next.

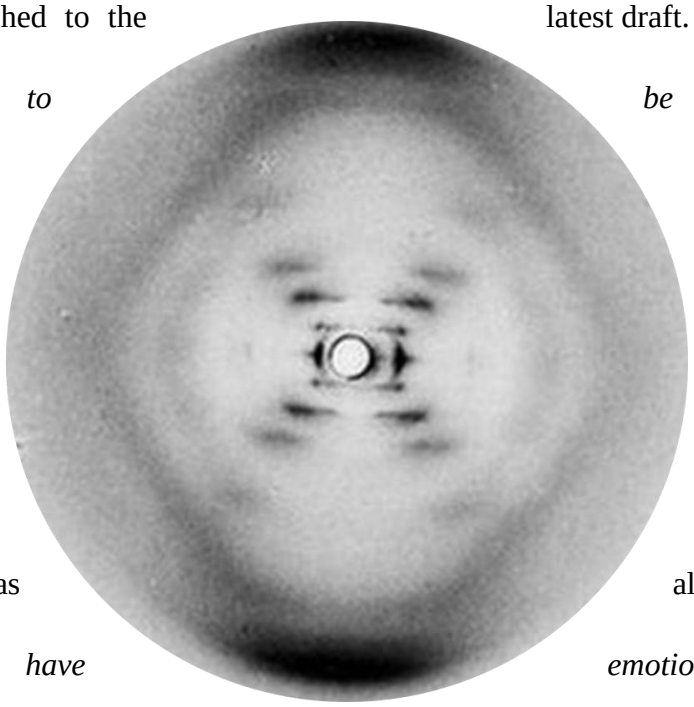
"Well, I think we at the very least deserve another drink, right?" Watson finally said.

"At the very least," Crick agreed.

And Watson lifted his hand to the bartender. “Barkeep, my good sir, please bring us two more of your finest! For we have just discovered the meaning of life!”

****

Rosalind sat at her desk. She was almost finished with the final draft of her paper, to be published (hopefully) (soon) in *Nature*, along with the grainy photo that confirmed her findings. She kept looking back at the image, distracted from the paper. The article needed a few little changes: shifting paragraphs, sentences, words. She also kept looking at the note Dr Randall had attached to the latest draft.



Remember to be human, Rosalind. Write like one.

The words haunted her, shadowed her like all the whispered comments in the lab. Always the same. In every workplace it was always the same.

Does she have emotions?

She wouldn’t know one if it slapped her through the face!

I don’t think I’ve ever seen her smile.

The muscles for that have atrophied.

Maybe if she smiled for once she might look attractive.

She might look human!

Rosalind glanced up as Gosling passed her open door. He paused. Stuck his head around the door frame.

"You doing alright there, Rosy?"

"Rosalind," she corrected, automatically, "I am fine. Just busy with some final edits."

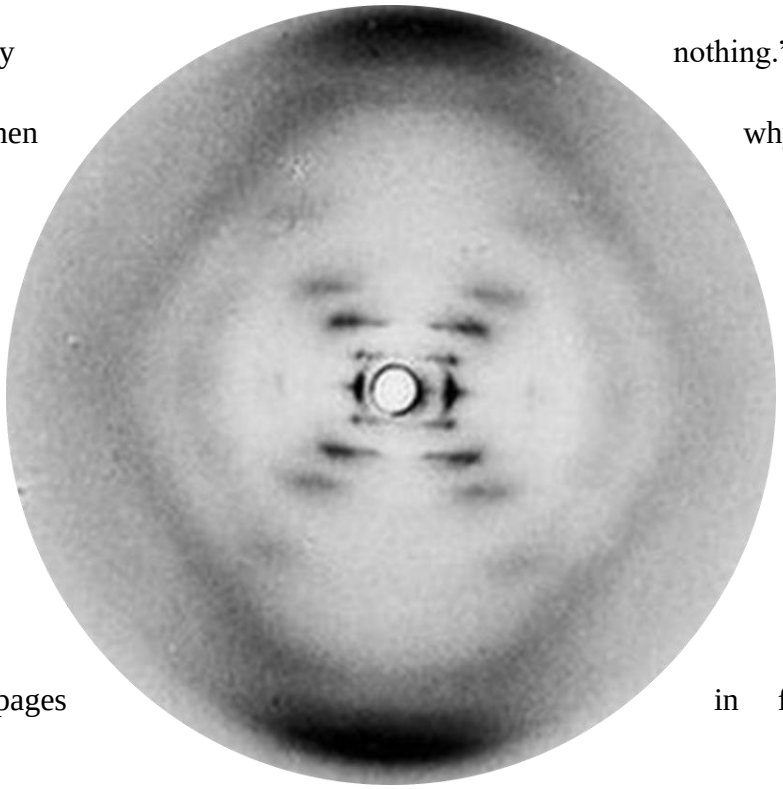
"Very good, then don't let me interrupt" Gosling said quickly, though he continued to hover, one hand gripping the door, the fingers tapping on wood.

"What is it, Gosling?"

"Probably nothing."

"Well, then why are we talking?"

"It's just that, there's a rumour: there will be other papers."



Rosalind's fingers instinctively reached for the pages in front of her. "What?"

"Other papers on our work, on DNA."

"*Who*? Who are they publishing? *When*?"

"…the rumours…probably published about the same time as ours. Maybe even the same issue."

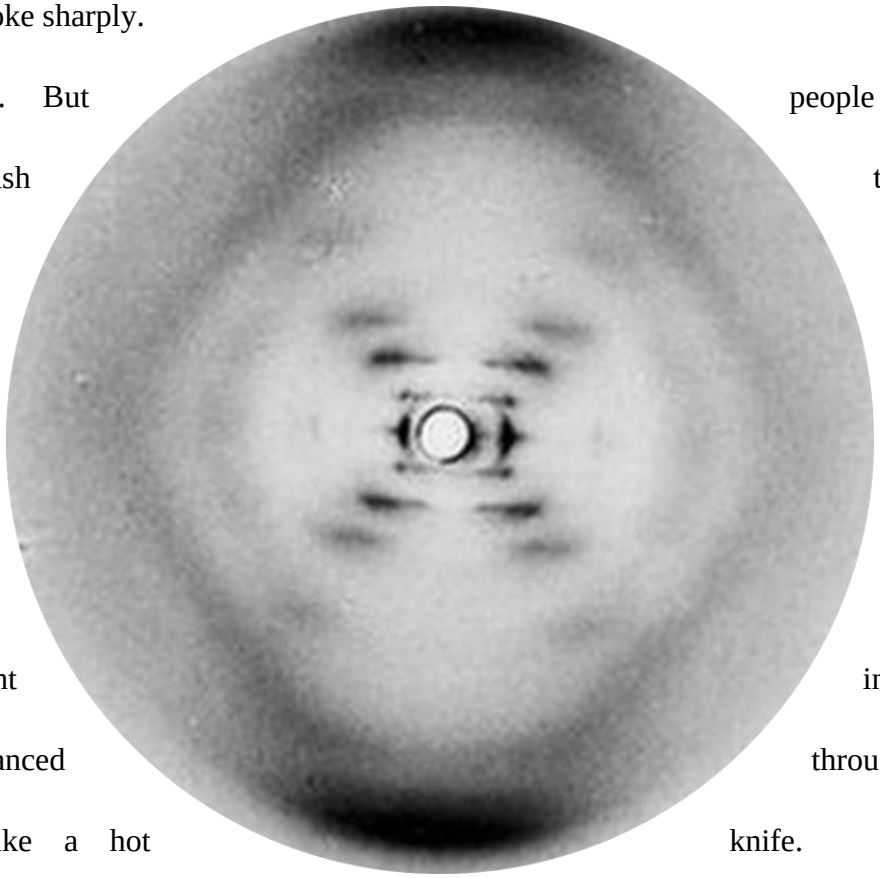
"*Who*?"

"It's likely those guys over at Cavendish."

"The ones who insist on building models when there is no conclusive evidence? It's ridiculous."

"Ros, I know how you feel about them, but some people are saying they might have figured it out."

"No! *We* have figured it out. I mean, we have proved it, and the photographs are much more conclusive that a model made on the strength of a guess and some stolen calculations." Rosalind spoke sharply.



"Yes. But people are saying the Cavendish team…might have…seen a photo."

Rosalind sat up straight in shock. A sharp pain lanced through her stomach, like a hot knife.

"I don't know."

"Well," Rosalind's hand was pressed to her stomach, feeling her skirt fabric straining against her belly. The clasp was close to breaking point. *Stress, it's just stress.* "We should focus on our paper, based in facts and calculations and everything that we have carefully done ourselves."

Gosling nodded and gripped the doorframe tightly one more time, before backing out altogether.

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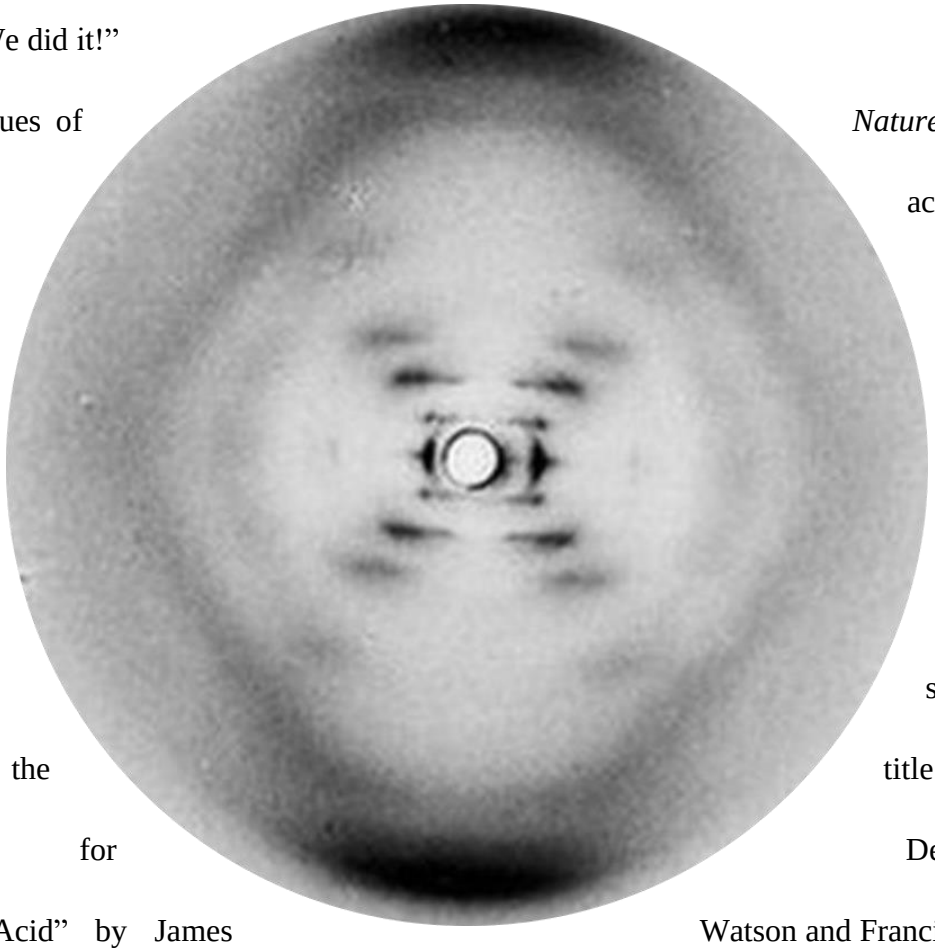
Watson popped the cork and the room erupted into cheers . Crick slapped his colleague's shoulder as Watson sloppily filled his glass.

"We did it!"



A few issues of *Nature* were spread across a desk. The first page was taken up with a neatly printed drawing of a double helix strand of DNA, and the title "A Structure for Deoxyribose Nucleic Acid" by James Watson and Francis Crick.

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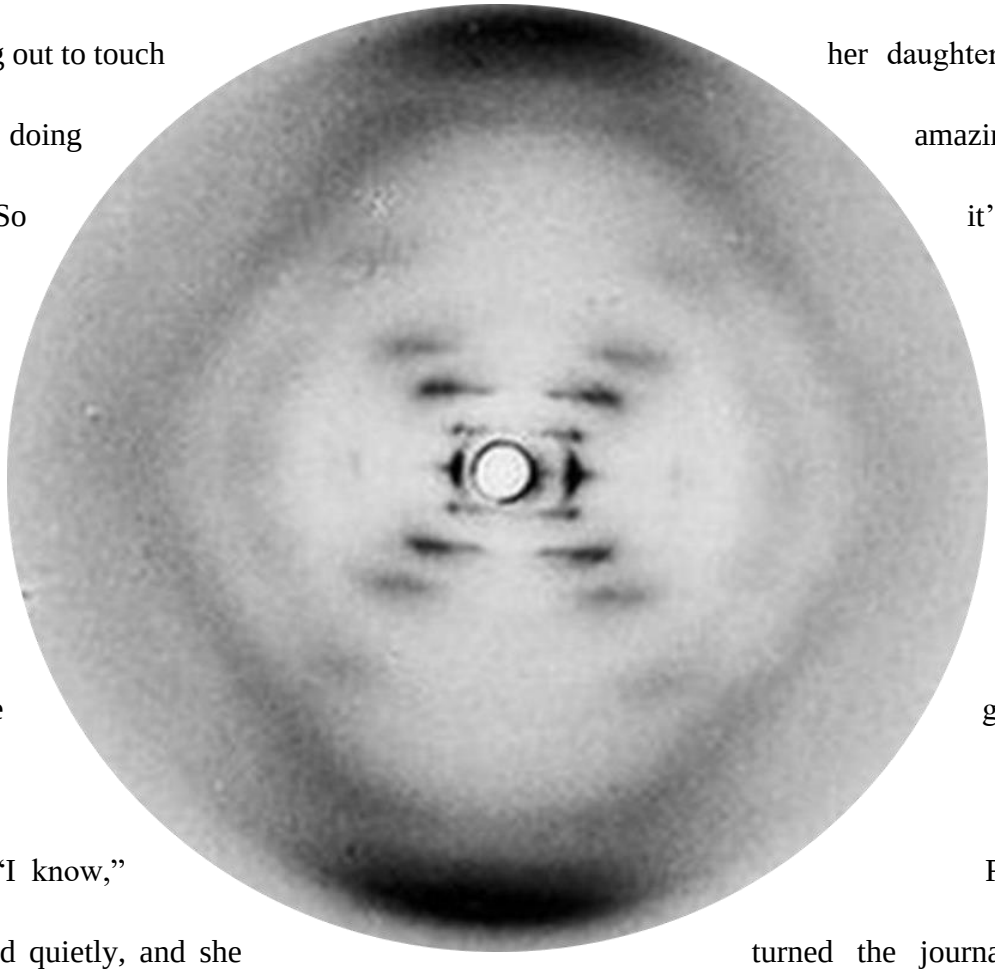
Rosalind turned the pages of *Nature*. She ignored the fanfare of Watson and Crick's single page. Ripped through Wilkins's paper, which simply backed up the men whose work featured more prominently in the earlier pages of the journal. Finally, at the end: there was the

photograph she and Gosling had made, and the article she had slaved over. When she had submitted the piece, it had felt like the start of a new era in science. Now, all her efforts read like an afterthought, boring calculations to back up the discoveries touted on the front page of the journal.



"Leave it alone, Ros," her mother sighed, tentatively reaching out to touch her daughter's arm. "You're doing amazing work now. So it's time to let this injustice go."

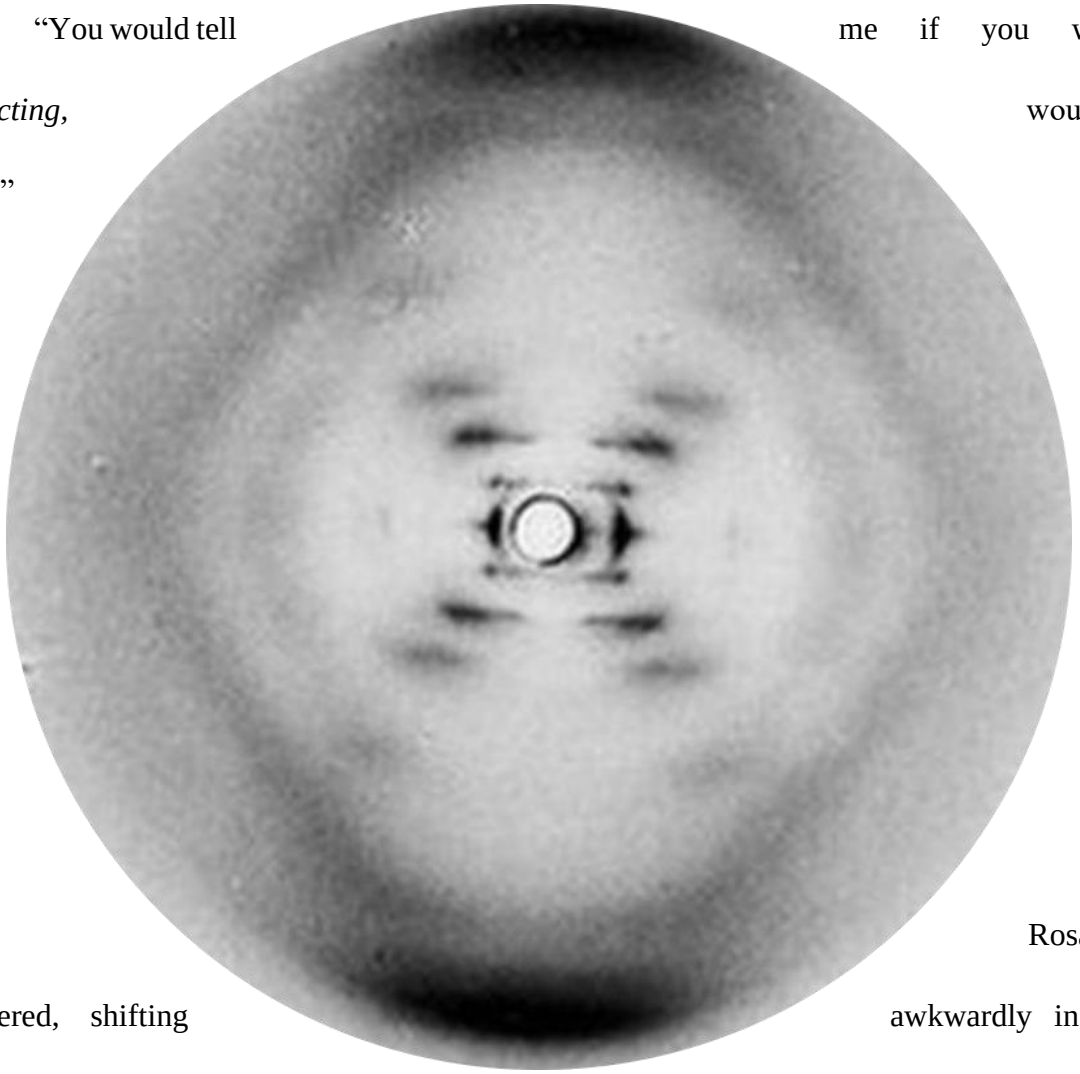
"I know," Rosalind conceded quietly, and she turned the journal over, face down on the side table. The work that she was doing now was important, researching the polio virus and its structure. She knew it could change the lives of many. But there was always a part of her that could not stop looking at the paper in *Nature* that had overshadowed hers. Especially, she was galled by the footnote on the scant one-pager by Watson and Crick. The footnote which claimed the paper's content was partially, maybe, perhaps, barely influenced

by some general understanding of the unpublished work of other scholars. She looked at the blank back page staring at her from the table and let her hand once again press against her stomach, bulging and straining under her fingers.

"Ros, dear?" Her mother's quiet voice, raised in question.

"Yes?"

"You would tell me if you were, *expecting*, wouldn't you?"



Rosalind muttered, shifting awkwardly in her chair. She glanced down at her stomach, which protruded much like that of a heavily pregnant woman.

"I would tell you, mother. I *would*. But it's not that, unfortunately. It is much, much worse."

Mouse Mother

Anne McLaren

@annemclaren - starting a new project today with @johnbiggers. Can't wait to get into the lab #newproject (09:02 AM Feb 3 1958)

| @johnbiggers - see you there.

@annemclaren - my job would be so much easier if we could just see what happened in the womb those first few days! What happens after fertilisation and before foetus? #ScientistProblems (10:34 AM Apr 8 1958)

@annemclaren - **@DonMichie** can you pick up Susie from daycare this evening? Going to be a late one today in the lab #ProjectMouse is almost ago! (16:14 PM Apr 13 1958)

| **@DonMichie** - Done and done, don't be too late for dinner (17:30 PM Apr 13 1958)

@annemclaren – Earky days. A mother's body hides its secrets well. Those first days of development a mystery. I'm a mother myself, and I don't really know! Keep trying. One day maybe I will figure this out for women who cannot have children #HappyMothersDay (11:00 AM May 11 1958)

@annemclaren - Daughter spilled her dinner all over my papers. Son laughing hysterically! Kids! **@DonMichie** do you want another one? #Number3 #LOL (06:34 PM May 14 1958)

| **@DonMichie** - ha ha! We'll never get anything done! (06:45 PM May 14 1958)

@annemclaren - **@JohnBiggers** and I are culturing 8 mouse embryos today. **@DrWhitten** - testing your medium - #fingerscrossed (10:11 AM May 24 1958)

| **@DrWhitten** - Am confident it will help your project immensely, keep me posted (10:55 AM May 24 1958)

|**@annemclaren** - **@DrWhitten** your medium seems to be working! Embryos can't tell the difference between lab and life. Perfect! (11:35 AM May 26 1958)

@annemclaren - #ProjectMouse successful so far. **@DrWhitten** cell growing medium imitates a mother's womb. Happy embryos. We can see what happens after fertilization. Hopefully reach blastocyst stage soon? (14:18 PM 26 May 1958)

@annemclaren - 4 sets of embryos made it! Almost 100% success rate #ProjectMouse (10:15 AM 8 June 1958)

| **@JohnBiggers** - you ready to start the next stage? #projectmouse (11:24 AM 8 June 1958)

@annemclaren – Big first today. Implanting blastocysts into living mouse mothers! HUGE step for us. Will they make it from medium to womb #SurrogateMothers (09:54 AM 15 June 1958)

| **@DonMichie** - Good luck! All the best today x hope this helps you feel a bit better. (10:23 AM 15 June 1958)

@annemclaren - Implantations successful! Leaving mouse mothers alone now to avoid stress on their bodies. Before: was weighing them every day to check weight gain. **@DonMichie** don't get any ideas! #Pregnancy (11:23 AM 23 June 1958)

| **@DonMichie** ha ha wouldn't dare to try! (13:34 PM 23 June 1958)

@annemclaren - Great news: mice mothers have started hoarding food in their cages. Really good sign. Usually means they will give birth soon #PregnancyCravings (09:45 AM 6 July 1958)

| **@annemclaren** – Ate all the snacks at home this evening, sorry **@DonMichie** ha ha maybe I should start hoarding food too? #PregnancyCravings #LOL (17:45 PM 6 July 1958)

| **@DonMichie** - Picking up more on the way home x #Number3 #imprepared (18:00 PM 6 July 1958)

@annemclaren - Felt the pups moving in the mouse mothers' bellies today. A week left to see if they'll give birth normally. Unprecedented we've made it this far #fingerscrossed #ProjectMouse (12:29 PM 10 July 1958)

| **@JohnBiggers** - Still can't believe it #ProjectMouse (14:21 PM 10 July 1958)

@annemclaren - Mother mice huge. Looks like they swallowed golf balls! I know how they feel. But at least I can still walk around #SecondTrimester (11:59 AM 12 July 1958)

@annemclaren - Red Alert! It's happening! #ProjectMouse (16:57 PM 14 July 1958)

| **@DonMichie -** Almost gave me a heart attack woman! Congratulations my love. Only a few months until our own delivery (17:12 PM 14 July 1958)

@annemclaren - Mothers and babies fine. All births successful and all pups healthy. Would never believe just dots in a petri dish a few weeks ago! #ProjectMouse #Successful (18:34 PM 16 July 1958)

| **@JohnBiggers** – Incredible. The world's first successful IVF. Congrats partner #ProjectMouse #Over (18:54 PM 16 July 1958)

@annemclaren - Article published today, cannot wait for you all to read it. Access it **@Nature** : https://www.nature.com/articles/182877a0 #ProjectMouse #FinalChapter (09:02 AM 27 September 1958)

Have You Been Tested?

Gita Ramjee

About Us

The clinic. Worn posters stuck to the walls. Dim fluorescent lights flickering overhead. Many full seats, yet the room is strangely quiet. Women seated along the walls. Women slumped in chairs, hands over faces. Women fixed to their phones. Eyes glance up. across. back. and forth. peeking at other women. Eyes never meet another's eyes. Behind the desk two women shuffling through papers, fingers clattering over keyboards. More female patients enter the room. Each time, the squeaking door draws the eyes of the room. Look at her.

Don't look at her.

Each woman is handed a clipboard and asked to fill out her details. Pen. Scratching on paper on wood. A small echo in the collective silence, so loud it overshadows the old aircon unit clanking in the ceiling.

How to Get Tested:
In South Africa you can get tested for HIV at most clinics and doctors across the country.

The Rapid Test: the RT is a cheap and quick test that you can get at a clinic or pharmacy that will give results in 30 minutes. However, it can take up to 3 months for the antibodies to show up in test like this.

The RNA Test: is a test that detects the virus itself and can detect it much quicker than the RT. The RNA test is not normally offered at a clinic or pharmacy. You may need to go to your doctor or a hospital.

Did you know: it is recommended that get tested for HIV once a year. If you have contact with multiple sexual partners you should get tested more often.

Pregnant? Breastfeeding? What You Need To Know:
If you are HIV positive this does not mean you cannot have healthy children.

Inform your doctor so that you can decide how to have your child without passing on the virus.

By taking HIV you can reduce the risk during childbirth and while breastfeeding.

Everyone can hear the nervous ticks and crosses entered on the forms. Can see a woman's silent counting as she turns back the clock in her head. Every time: past encounters, past days, past periods.

This time?

At last a name is called. Sometimes, like this time, it takes a moment for the name to be answered, a woman remembering the name she had given, wanting to forget. Then the woman gets up, and heads to a different room. As she does, one of the women behind the desk gives her a passing touch on the shoulder. An awkward smile. A tense silence.

In the other room, a nurse. She reviews the form, re-asks in person the questions already answered in rushed blue ink. There is another woman there too. She queries each patient: can I ask you some questions? Would you mind being part of a study? Something bigger we're trying, something new. She has a kind smile, and a long list of questions. The patient hesitates but the nurse encourages her, says she can remain anonymous.

Why Women Are More At Risk

Women and girls are disproportionately affected by HIV because of the inequalities that exist in cultural, social, and economic status in South Africa.

Women are often restricted from having autonomy over their own bodies and their social lives, reducing the chances of them having access to sexual health education and services.

Women in South Africa face increased risks of gender-based violence and sexual assault, putting them more at risk.

"You do not need to give your name."

The woman agrees. Answers all the questions about her experience of living with *it*. How her lifestyle might have influenced things. It seems impossible to know. Can a woman be certain?

The woman with the questions had for a long time looked at the clinic with the ragged posters and the flickering lights and the silent women and the hidden glances and had wondered. What would it be like to be here?

Under different circumstances.

When she arrived to start the study, she did not know what she was expecting to hear when the women spoke. Or, more truthfully, she did not really expect to hear anything other than what everyone told you to expect.

Loose women.

Women with low morals.

Low standards.

Low self-respect.

TAKE THE STEPS! Know your status!

South Africa has made huge improvements in HIV testing and education. As of 2018, 90% of people living with HIV were aware of their status. We have the largest ART (antiretroviral) programme in the world and we were the first country in sub-Saharan Africa to approve PrEP (Pre-Exposure Prophylaxis), a medicine to prevent HIV. Knowing your status is an important part of getting the treatment you may need to live a healthy life. So get tested, know your status, and let's keep breaking the stigma of HIV.

But the stories they shared were simply of women and their difficult lives.

Grace had no money.

Jane had a family to feed.

Faith had a husband who refused to use protection.

Sinethemba's partner forced them to have sex with other partners.

DID YOU KNOW?

There are 7.5 million people living with HIV in South Africa, as of 2019.

More than half of the people living with HIV in the world are Women.

Women between the ages of 10 and 24 are twice as likely to contract HIV than men of the same age.

Helen's body was not hers.

Patricia's body had not been hers since before she had known what it meant to have a body.

And Gita. At last, after all her years of thinking and studying and wondering. Gita knew she was in right place.

For More Information and Support: HIV and AIDS Helpline: 0800 012 322

Archive

Mary Anning (1799-1847)

Mary Anning was a fossil collector and one of the earliest palaeontologists. She collected fossils from the coast by her home town in Lyme Regis, England, and sold them to collectors (a common past time in this period) (Clary and Wandersee 153). However, she also became fascinated by the concept of the past and, despite her limited education, decided to educate herself on science, geology, and palaeontology. Her research allowed her to accurately identify many rare fossils, including the first complete *Plesiosaurus* skeleton ever discovered (Burton 340). She was never accepted in the scientific community for her knowledge or for the discoveries that she made, and was denied not just membership to the Geological Society of London but access to any of their meetings, even as a guest, on the basis of her gender (Burton 340).

Rosalind Franklin (1920-1957)

Rosalind was a chemist and X-ray crystallographer whose work would change our understanding of DNA and its structure. She also made significant contributions to the study of viruses, RNA, coal, and graphite. Despite conflict with the men that she worked with, who did not think that a woman should be allowed in their labs, she and her assistant Gosling successfully photographed DNA for the first time (Gibbons 66). This allowed them to understand the physical structure of DNA. However, Watson and Crick, scientists who were in conversation with Franklin's former colleague Maurice Wilkins, were given access to her photographs and calculations and used it in their landmark paper on DNA structure (Gibbons 63). As a result, Franklin's work was seen as merely backing up their work and she did not receive the Nobel Prize alongside the other scientists.

Wangari Maathai (1940-2011)

Wangari Maathai was the first African woman as well as the first environmentalist to ever receive the Nobel Peace Prize (Muthuki 84). She was born in rural Kenya and won a scholarship that allowed her to study biological science in the United States. She returned to Kenya to complete her PhD and in doing so, became the first woman in both Eastern and Central Africa to do so. Maathai was very aware of the environmental destruction happening in Africa and dedicated the rest of her life to fight back against the governmentally backed forest clearances that were happening in Kenya. She founded the Green Belt Movement in 1977; the purpose of which was to plant as many trees as possible to replace those lost to deforestation (Maathai and Goodman 202). This movement became a powerful project that gave women work and confidence, as they were encouraged to plant their own tree nurseries. This created a power shift that allowed women to have control over their firewood supply, boosted their confidence in their status in life, and left them with time to pursue other jobs and hobbies. At least 30 million trees have been planted due to the project (Maathai and Goodman 202).

Anne McLaren (1927-2007)

Dame Anne McLaren was a geneticist who played a crucial role in the advancement of embryology, greatly contributing to the global understanding of reproductive biology. She was the lead researcher on a pioneering project that reported the first successful birth of mice from in vitro fertilisation. She was also a vocal advocate for governmental assistance of childcare and was on the committee that discussed the implications and technologies required for IVF in humans. She played a crucial role in the development of both IVF procedure and the policies surrounding it (Rossant and Hogan 609).

Maria Sibylla Merian (1647-1717)

Maria was a naturalist and scientific illustrator who is best known for her series of drawings detailing the metamorphic of caterpillars and moths. She and her daughter Dorothea travelled to Suriname in 1699 and the drawings that they made during this time were revolutionary, documenting many plants and animals that had never been seen before (Paravisini-Gebert 10). She was one of the first to add insects and their relationships with plants into scientific illustration, widening the understanding of how interspecies relationships worked (Etheridge "Maria Sibylla Merian" 15). It is also widely believed that she was the first to detail the process of metamorphosis in caterpillars (amongst other creatures), and the life cycles of plants.

Cecilia Payne-Gaposchkin (1900-1979)

Cecilia was a British-born American astronomer and astrophysicist whose groundbreaking doctoral thesis proposed correctly that stars were comprised primarily from hydrogen and helium. Despite her struggles to gain a degree as a woman, she published her thesis in 1925 that showed that the current understanding of the universe had been misunderstood (Horn 1354). Her research was an integral part of the future discovery that hydrogen is the most abundant element in the universe. Her thesis was widely discredited by other scientists who dismissed her ideas as ridiculous, and she changed the wording of her paper to make it less conclusive (Horn 1354). Only a few years later other scientists reached the same conclusion, but she never received any recognition for her work.

Gita Ramjee (1956-2020)

Gita was a Ugandan-South African scientist and researcher who worked primarily in HIV prevention. Following her PhD work in childhood kidney diseases, she became the head of the

largest unit of the Council (the HIV Prevention Research Unit). She was a part of the expansion of HIV prevention and treatment clinical trials in Durban (Offord). She felt that it was important to not only improve clinical trials but also expand on HIV prevention education and care. She recognised that women are at a disadvantage in the system and that more help was needed for reproductive care and HIV prevention for the women of South Africa (Genzlinger). She received many awards for her work and published more than 170 articles during her career. She passed away due to COVID-19 complications in 2020 (Offord).

Gladys West (1930-present)

Gladys Mae West was a mathematician who played an integral role in the development of technology that would lead to modern day GPS. She worked hard to pursue her dreams of education and worked at the Naval Proving Ground (now Naval Surface Ware Center) in Virginia until her retirement (Glorfeld). She was only the second black woman to be hired there, and one of four black employees overall. She was a part of the award-winning astronomical study that proved the regularity of Pluto's motion relative to Neptune, and was later the project manager for the Season radar altimetry project, which worked on the first satellite that was able to remotely sense oceans. Her most important work was entered on putting together models of the Earth's shape using satellite data, and she was able to construct an accurate model of the Earth, which would become the basis for GPS (Reynolds). Her contributions were only recognised in 2018, after which she was inducted into the United States Air Force Hall of Fame (Reynolds). She completed a PhD in Public Administration in 2018.

Creating an Imaginative Archive for Marginalised Women in Science

Critical Framework

Introduction

Androcentric history, it sometimes seems, has conspired to place women at a professional disadvantage. Though women may have lived extraordinary lives or made invaluable contributions to their fields, their names have often been left to the last paragraph of the historical account, or relegated to the footnotes – or have not appeared in the paper record at all. Pages and pages of praise for famous men. Volumes and volumes which give but a nod to women, habitually in the tired forms of Queen Victoria or Joan of Arc. Of course I am being provocative here; using exaggeration to carry my point. I appreciate that this omission of notable women achievers *has* changed, under pressures from feminist scholarship, in particular, but in regard to my interest and focus in this MA thesis, the lack of popular knowledge of women in science, for instance, persists. In this section of the MA, I attempt to explore what can be done to change the gender divide in science and how literature can be used to highlight the lives of female scientists whose stories have been excluded from the traditional historical archive.

Behind the fact that female scientists' names are forgotten or unknown, there is a much deeper issue that is entrenched: despite a continued drive by some (whether institutions or individuals) to counter the gender inequity in many scientific fields, the imbalance of female to male scientific scholars and science professionals remains. Women may have "risen to the challenge" of being able to perform well in scientific and mathematical fields, but they are still seen by some employers as "a bad investment" because of their perceived family responsibilities, and such prejudice has led to a continued underrepresentation of women in scientific fields, with women too easily relegated to menial lab assistant positions, and rarely seen in high ranking roles (Institute of Medicine xii).

Also relevant to my MA project is the fact that there is an imbalance of social value attribution between the so-called soft and hard sciences, the social sciences and the 'pure' sciences. Literature (for example) has a tendency to be perceived as less important than fields of scientific data and research, and to be considered a skillset and discourse that plays no part in our understanding of the scientific world. This is frequently true in popular belief, and also has purchase in academic circles. There has been some debate about whether the two fields should or should not overlap more, but there are some studies that suggest that the overlapping and intertwining of the two fields could be beneficial for both sides. For example, a study from the United States National Science Foundation showed that students found it easier to understand and retain information when it was presented in short story case studies instead of plain facts (Clough 12). If STEM fields have opened our eyes to how the world works, disciplines such as literature in the arts and social sciences could provide the means to show how scientists work as well as allowing for a re-storying of science; changing the way that science is perceived by non-scientists and rewriting science's preferred historiography. Through literature the world of science may become more easily understood to those outside of arcane specialist spheres of study, and it is possible that literary narratives may have the capacity to enable a more intriguing, animated excavation of the received historical record of scientific discovery.

The collection of short stories *And Other Scientists: Stories of Women in Science*, written for the present thesis, is intended to contribute to the body of fiction that has started to address the way that women have historically been given less space in historical narratives of science. My short stories aim to contribute to a lively imaginative archive, that opens a door between the worlds of science and literature. In this way, I am contributing to the "women's archives" that have been attempting to change the fact that women's lives are not "adequately documented in

traditional repositories" and which seek to offer readers a different way to encounter significant historical discoveries by female scientists (Mason and Zanish-Belcher 344).

The stark gender imbalance in the sciences is not a new phenomenon and (with some variation) originates in the way women have been treated as secondary subjects throughout history, and across cultures. As just one historical example, consider Mary Anning, an English marine fossil collector and early palaeontologist in the 1800s who found the first complete Ichthyosaur fossil, and subsequently also a fossilised Plesiosaur skeleton, and that of a Pterosaur (Burton 340). Anning was denied access to the prestigious Geological Society of London – simply because she was a woman (Burton 340). Only in 2010, 163 years after her death, did the Royal Society include Anning in the list of ten British women who have exerted the most significant influence upon the history of science (Cassleton et al.). Or consider that in the early 1900s Cecilia Payne-Gaposchkin was denied a degree at Cambridge because the institution did not grant degrees to women until 1948 (Soldati et al.). Or: in the 1950s Rosalind Franklin was seen as a mere lab assistant instead of as the head researcher of her own breakthrough project which underpinned the discovery of DNA (Lee). Or: in 1974, Joceyln Bell Burnell, an astrophysicist, lost out on receiving a Nobel Prize for her work; the award was given to her male supervisor instead (Saini).

Such marginalisations persist. Contemporary research continues to show that there is a measurable disparity between the place and acknowledgement of men and women in science, with significant "gender inequalities in hiring, earnings, funding, satisfaction and patenting" (Sugitmoto 211). As science journalist Ed Yong notes, "women in science face a gauntlet of well-documented systematic biases" (Yong "I Spent"), and as recently as 2019, a women-only USA space mission was in jeopardy because the suits for astronauts were produced solely in

male body sizes, which bias would place women's safety in jeopardy (Fortin and Zraick). (A similar situation has obtained with PPE equipment in the Covid-19 epidemic). So we are not dealing only with 'the past'; the ceilings, gate-keeping and stereotypes carry into the present of the twenty first century. Research shows that there is no doubt that the marginalisation and biases are proven, and remain currently detrimental to women. As mentioned above, women are less likely to be hired as scientists or to receive grant funding, and research also suggests that female scientists are referenced far less than their male counterparts, and that their scholarship is less familiar to those outside the scientific community (Bendels et al.; Schiermeier; Kuo). Despite supposedly massive strides in overcoming gender disparities in scientific fields, current research attests that women are often (mistakenly) seen from a young age as less intelligent and lacking in the 'unemotional' qualities necessary to exist in the world of science, though these ideas have no basis in fact (Institute of Medicine xii). While these biases may no longer be as brazen as they were in the past, they endure, and this continues to fuel the idea that women and science do not comfortably coexist. It is therefore no surprise that women are also much less likely than men to enter the sciences to begin with, which does nothing to change the gender imbalance or improve attitudes. The tautologies are painfully evident, and yet entrenched.

There are many theories explaining why women are less likely to embark on scientific careers, but the scholarship can be effectively summarised via three main points. In effect, here, I am offering an angle on the historical 'storying' of women *out* of science, a situation my creative work wishes to redress. Firstly, we must consider how women perceive science in their daily life experiences during their formative years, and how this affects their study and career choices. This includes how women and their intelligence are often negatively treated in STEM subject classrooms, as well as the methods that the media and popular culture use in continuing

to portray science as a mostly male dominated field that is unfriendly towards women (Schmidt and Nixon 255).

Secondly, when we consider the reasons why there are still fewer women in scientific careers, there is research to suggest that the way in which STEM subjects have been taught throughout history and how they are taught in the modern era, may be affecting the way that young people view the sciences as a whole (Clough "The Story" 1). In the past, the sciences were taught more practically, with greater attention given to the lives of the human scientists and their involvement in scientific discovery (Clough "The Story" 1). Historically, too, women were also not given access to scientific study or were actively discouraged from it. Studies suggest that in the modern era the way in which the sciences are being taught has changed, and not always for the better. The sciences are paying less attention to the human scientist figure and the processes behind scientific discovery, and are more focussed on the facts, which are mistakenly believed to exist as given truths, in themselves (Clough "The Story" 2).

Thirdly, one way to influence for the better women's perspectives about science and the scientific community might be to start with the popularising of inspirational role models. Giving new contemporary energy to early feminist initiatives around re-dressing stereotypes of women, I believe that uncovering the stories of women in science who have succeeded in the past and those who are succeeding now, and creatively depicting these narratives in the form of short fiction, may open the door for more young women to see that their negative assumptions about their scientific ability and their hostile perceptions of STEM fields may be unfounded. Exposure to careers, in any field, as well as to influential historical figures, provides an insight into what a potential future might look like in choosing a career path (Etzkowitz et al. 13). It also begins to change the conversation, moving away from only showing women the

problems and obstacles related to being female in the field of science and providing positive insight into their own abilities (Etzkowitz et al. 13).

The choice to use short stories as a medium for creating an innovative form of archive of women in science was deliberate. Aside from the obvious advantage of a short story collection, which allows for multiple stories to be shared in one volume (and for the moment leaving out questions of creative treatment), short stories are a useful and easy way to share something with a readership, whether this is a life story, a moment, a fact, or a means to reinvent the past and how it has been told. Short stories are often used in the area of historical fiction for this very reason. Historical fiction is fiction that is based on or engages with historical events by imaginatively reworking historical fact and attempting to convey some of the spirit of the social issues and conditions of that time period (Beck et al. 547). It is a means of sharing historical knowledge through an approachable medium to readers outside of the academic realm of history, and is often a mix of received historical document, realistic detail, inventive affective characterisation, and creative interpretations or assumptions about the past. Particularly in cases where we lack exact knowledge of people's lives, culture, or relationships it is possible to creatively fill in the gaps by originating a story from the facts that *are* known. Writing these scarce received details into a narrative allows for readers without historical knowledge of the time, era or place in which the story is set to understand the situation through the author's creative treatment of the protagonist and both her interior and exterior situations (Beck et al. 547).

In regards to my creation of a small, illustrative archive of women in science, the collection being in itself a piece of historical fiction and a collection of short stories, the short form is an important and, I believe, a crucial part of the archive. Novels could be written on most of these

women in their own right, as has been done for some of the women I am writing on. Consider for example Kim Todd's *Chrysalis* (2007),based on the life of Maria Sibylla Merian, and *The Fossil Hunter* (2011) by Shelley Emling, exploring the influence of Mary Anning, books which delve into their lives as a whole and convey many more details about all of their scientific successes as comprehensive career. However, there are some women (of my chosen few, but also on a wider global scale) for whom this would not be possible, due to the lack of detailed information on their lives. Their lives were not considered important enough be recorded, which is, of course, one of the main points of my story collection – to acknowledge and draw attention to the gaps in historical archives in regard to women in science. These gaps are both physical and metaphorical. As I will discuss in more detail in Chapter 1, the traditional archive is a collection of documents, a physical place where words and information are stored (Bernard-Donals 704). However, an archive cannot ever be complete as there are always stories and narratives that are left out or untold (Bernard-Donals 705). The same can be said of the traditional archive of science, in that the stories of women and their achievement are often not included in the historical narrative. My choice has been to use key selected female lives in science to create a sense of multiple missing stories, so that the stories I do elect to write, made up of moments in the lives of women scientists, function in part as a socio-biographical testament to their particular accomplishments and situations, but *also* have the potential power to reach beyond the individual, more expansively conjuring the lives that may always be lost due to the limitations of historical archiving practices. My creative work thereby suggests the severely flawed, hierarchies of gender-prejudice on which histories of science have been (and still are, to some extent) premised. In effect, through my collection of stories, I can highlight the fact that there are many women like the few represented in this creative archive, who also have stories that should be told. As Mason and Zanish-Belcher note, the establishment of women's archives (that is archives that are specifically designed to highlight women's lives

and achievements in contrast to the traditional archives that historically have not included women in equal measure to men) has not "kept pace" with the analysis of women's inequality (345). Though measures have been taken to note and attempt to improve the representation of women in the workplace, in historical narratives, and in society, there is still work to be done. My collection is representative of the fact that this issue is not just the case of one woman whose story has been overlooked, but that this has been the historical condition for many women – some of whose contributions to science we may possibly never discover.

Short stories also useful in their ability to be used in a learning and teaching capacity, both inside and outside the classroom. (This issue is expanded on later in the thesis.) Stories and storytelling are often traditionally considered by scholars in the sciences to be "baseless" and unnecessary, mere features of the useless and indulgent Humanities (Dahlstrom 13614). But, as mentioned, there are studies to suggest that a merging of methods could be extremely beneficial to students (Clough "The Story" 12). STEM field textbooks are often lacking in historical background and the human nature of the sciences, focussing on facts over context. However, students who were presented with short fiction that explained scientific concepts reported an improved understanding of the subject matter, a better understanding of how creativity influences scientific research, and how scientists themselves play a role in the discoveries that they make, and how this influenced the culture and society of their time (Clough "The Story" 12). In the case of my collection of stories, the same principles apply.

In general, the sciences are perceived as an area that is opaque to lay people. Science has the popular reputation of being exceptionally difficult, founded on complex numerical skills, data processing and statistical abilities, and applied knowledge. Members of the general public are not often exposed to the realm of science outside of textbooks and scientific articles in

education settings, the doctor's waiting room, or the Google search for symptoms of an illness. However, providing more approachable forms of this knowledge is paramount in today's technological culture, where most non-experts (including students in STEM fields) have access to mass media platforms such as YouTube, where they are exposed to large amounts of information in an easily digestible form (Dahlstrom 13614). From the vantage of literary studies and creative writing, I am suggesting, short stories can be a wonderful complementary medium, facilitating what I call the knowledge translation of complex scientific ideas of science for a non-expert audience, allowing for a breakdown of the divide between the seemingly impregnable world of science and the ordinary.

Lastly, in this research component of my MA, I will be exploring the literary influences that have affected the formation of the short story collection, from content to form. Creating a collection of short stories based on the lives of real women required me to seek out examples of literary authors who have created works of short historical fiction, who write on women in empowering ways, and who experiment with the form and structure of short stories. One of the main influences was the collective works of Andrea Barrett, an author known for her short fiction which incorporates elements of historical narrative (whether invented or based in reality) and stories that include science as an accepted, unexceptional part of her female characters' lives. Scientists are often seen through a veil of mystery, furthering the view that science is not a familiar ground in the lives of most people. Barrett's stories show people with normal lives who happen to do science, as opposed to how scientists are often perceived as living arcane, mysterious lives in laboratories, surrounded by strange machinery. This is an important part of representing the women I have chosen to write on; that scientists themselves are people living average lives (not far from the experiences of people in other fields of work) and female scientists are a part of this scientific world in an equal capacity to men. Other

authors I explore as influences include China Miéville for works of experimental short stories and Roxanne Gay for her stories on the representation of women. In this section I explore the ways in which each woman of my collection is represented through the form of their story (from a more traditional story form to more experimental pieces) and the influences that helped to form the collection.

In conclusion, the critical framework of the research component of this MA is an exploration of the gender disparity in the narrative of science, how (short) fiction may play a role in changing the general public's perception science and scientists, and how the collection of short stories that I have written (based on the lives of female scientists and the gaps in existing archives) contributes to the growing base of literature designed to highlight the contributions of women in scientific fields. In a time where women's inequality in society, and in the context of this study their continued representational disparity in the field of science, is being questioned and fought against, I believe that it is important to explore the various ways in which the representation of female scientists can be improved and how literature could play a role in changing the way that science is perceived in the popular imagination.

Chapter One: Representing Women in Science

Why is the Field of Science still not Amenable to Women?

i.) A History of Exclusion: From the Classroom to the Workplace

Although there has been an increasing emphasis on noting the representation of women in the sciences, there is still an obvious disparity between the genders in STEM fields. Women are underrepresented in many areas of science, are more likely to leave their field for other jobs or careers, and are much less likely to continue into higher positions if they do remain in their scientific fields (Merrick 744). Though in current times there might not be an obvious or deliberate movement to divert women away from the sciences, it is hard to explain why so many women do not choose to pursue STEM subjects and why they harbour negative feelings towards them (Schmidt and Nixon, 255).

This is not a new problem, and it is not something that we are just becoming aware of. In 1980, Arnold A. Strassenburg and Lester G. Paldy presented a paper entitled "Women in Science," in reference to a bill presented to the United States Congress with the same title (110). This bill was intended to challenge the inequality of women in the sciences, lead to opportunities and employment for women in the field, and improve the education of women in mathematics and science (Strassenburg and Paldy 110). It was suggested that for changes to be made, efforts should undertake:

> (1) to prepare women for scientific, engineering, professional, and technical careers;
>
> (2) to increase opportunities for the employment and advancement of women in science and technology;

> (3) to improve the science education of women, with particular emphasis on mathematics education;
>
> (4) to promote the literacy of women in science and mathematics;
>
> (5) to encourage the participation of minority women in scientific and technical education and careers;
>
> (6) to encourage the participation of handicapped women in scientific and technical education and careers; and
>
> (7) to educate an inform the public concerning opportunities in science and technology and the importance of participation of women in science. (Strassenburg and Paldy 110)

At the time, Betty Vetter, the Executive Director of the Senate Subcommittee on Health and Scientific Research, had reached the conclusion that without significant changes to education, inclusion, and mindset towards women's inclusion and equality in scientific fields it would take at least 40 to 50 years for women to be seen as equals to men in this field (110). Today, in 2020, it has been 40 years since this prediction was made and while some of what was suggested for change has happened, in some countries, such as more equal education for women in science and mathematics, and a public understanding of women being an important and equal part of scientific discovery (in most of the western world), there is still work to be done. As my study emphasises, women are still underrepresented in the sciences and are less likely to achieve high ranking positions in their fields (Merrick 744). One reason for why this is still a problem is not a "lack of interest" in science, but rather a combination of "social, cultural, economic, and political factors" that are turning women away from pursuing careers in science (Merrick 745).

Many researchers believe that these attitudes develop from the way that women are treated during formal scientific education from a young age, which leads young women to believe that they do not have the mental ability for science, therefore developing "negative attitudes" towards the field as a whole (Schmidt and Nixon 255). This attitude is not new, and stems from the ways that women have been treated throughout history. As mentioned in the Introduction to this research component of the MA, numerous women who made important contributions to the field of science were dismissed on the basis of their gender. Today, scholarship shows that there continues to persist a measurable disparity between the place and acknowledgement of men and women in science. A ten-year long study by R. D. Simpson and J. S. Oliver, for example, highlights what is considered to be one of the main issues. In this study American adolescents' attitudes towards science and their achievements in it were documented, while also looking at the way that school life, home life, and individual perceptions influences these attitudes (Schmidt and Nixon, 255). The outcomes showed that the young women who participated in this study harboured more negative attitudes towards science than their male counterparts and achieved worse scores (Schmidt and Nixon, 255). However, the same young women consistently reported that they wanted to achieve better in science and their responses demonstrated more motivation to achieve than did those of the young men. Such imbalance is partially explained in reference to the negative attitudes of others, namely male peers and educators, in STEM classroom settings, towards these young girls and how this can prejudice and even irreversibly change their attitude towards themselves and their own achievements (Schmidt and Nixon, 255).

The above conclusion – that the way women are treated in science classrooms can have a damaging effect on their opinions of themselves and their abilities – is a representation of the entrenched sexism that lies in scientific teaching. It is suggested that many teachers treat pupils

in their classes in different ways based on their sex, even subconsciously, and even subtle wording and praise can have long lasting effects on pupils' attitudes towards certain subjects (Schmidt and Nixon, 255). Though women are now less likely to experience anyone directly challenging their intelligence or abilities in the sciences or mathematics, this does not mean that they are not reaching the conclusion themselves, a subtle undermining of their confidence due to the way educators treat them in the classroom as well as the continued presence of stereotypes that present scientists as predominantly men. Various studies have shown that textbooks and educational materials in science classrooms rarely show women engaged in scientific pursuits or show women as role models for young women, and that many teachers themselves tend to have a bias towards men in science classes (if only subconsciously) (Steinke "A Portrait" 409). This has led to young women developing the opinion that scientists (by nature) are men, science is a man's subject, and that they do not like and will not be able to do science (409).

Notably, this idea is not only present in the minds of students, but appears to be unconsciously entrenched in the imaginations of educators, which may be adding to the continued sexist ideas that percolate in general society. Here is an example. Deborah A. Gober and Denise S. Mewborn use an activity in their teacher education courses called 'Draw a Mathematician' (32). This exercise is designed to show how ingrained gender issues can be, even in teachers who might consider themselves to be without bias. The exercise asks the participants to draw a mathematician and then describe what they have drawn, particularly focussing on "gender, race, age, tools, social acceptability, inside or outside, alone or with people" (Gober and Mewborn 32). It was often the case that teachers drew stereotypical mathematicians, describing them as older (generally white) men, working by themselves, creating mathematical formulas in a room alone somewhere (32). This visual image is one that has carried through from the

past: the idea of an intellectual man (even a male genius) sitting alone in deep thought as ideas merely 'arrived', came to him via inspirational chance. Such a visualising exercise makes it clear that women are not imagined to form a normalised part of the visual image of science, and this preconception – a misconception – goes on to influence educators and students alike. A key problem with educators who have internalised a sexist view of the sciences is how this translates into their treatment of women in a classroom setting, with women often perceived as a group that will not succeed in STEM subjects (Riegle-Crumb and Humphries 291). Despite evidence that there is often not a gender-based disparity in test scores in science subjects (with girls in the majority indeed scoring *higher* than boys in many cases) there is still an indication that many teachers place more faith in their male students, evidencing the misperception that males are inherently more talented in STEM subjects (Riegle-Crumb and Humphries 293). In several studies (Fennema et al. 1990; Michigan, Jussim and Eccles 1992; McKown and Weinstein 2002), it was revealed that teachers consistently considered their male students to be better at mathematics in scores and ability, despite a lack of gender disparity in the test scores (Riegle-Crumb and Humphries 293). This perceived gap in intelligence and associated performance is something that young women are likely to internalise, and this can self-sabotage their future education and career choices, turning them away from scientific careers.

Another influence of educator-based sexism comes into play in classrooms where gendered stereotypes are used in various settings, such as when creating an example to complement a math problem, or when dividing the class into groups and giving different genders different tasks. For instance, it is common for women to be dealt the role of 'secretary' or note taker in a group learning situation, even when there is no perception that they have any specific or special skill in this area (Kommer 45). Studies also show that in the classroom setting, and from a young age, men are treated better in classes like mathematics and receive more attention

from educators (Gober and Mewborn 33). It is thought that girls are usually quieter and less demanding of attention in a classroom setting, meaning that boys are often given more of a chance to speak and contribute (33). This may exacerbate the fact that women often feel discouraged and "disconnected" from subjects like science and mathematics, thereby lessening the chance of them pursuing a career, or even higher education, in these subjects (33–34). Aside from their participation, women also experience a disconnect from subjects in the ways that these subjects are taught and the stereotypes that are present in language and examples used by textbooks and educators (Myers 331). Studies suggest that educators (particularly male) continue to use stereotypes of gender roles when talking about jobs and sexist jokes are often made that demean women and their intelligence or abilities (331).

As implied above, the use of gendered wording can also play a role in women's perception of themselves in the sciences. This in particular is something that is not only seen in classrooms, but persists in general society and the workplace. From childhood seemingly small, ostensibly innocuous areas of language, such as addressing young girls as "sweetie" and boys as "buddy" or "pal", can make a significant difference in the way that men and women view themselves and this may cause long lasting effects on their perceptions of their own abilities. 'Sweetie' may not learn to view herself as a person with potential scientific prowess, and may instead inculcate the supposedly more feminine traits a culture prefers, such as sweetness and docility, or perhaps an alluring physical attractiveness. Tanya Lovell Banks argues that the subtle wording used by teachers and other authority figures towards women comes as a response to the changes made to remove overt sexism from conversation in the 1970s and 1980s (137). The language of examples and the wording of textbooks still habituates "he," "his," "man," and "men" to talk about general experiences, obliging women to accept this wording as a part of their subordinate experience of life and their interpretation of the world. Such naturalised

phrasing (which continues into life beyond school and tertiary education and conveniently masks as gender neutral), reinforces the idea that the world is naturally run by, led by, and prioritises as normal the experience of men (331). Most of the biases that educators hold, related to gender, are unfounded revealing them to be based in societal stereotypes surrounding gender and intelligence. Perceptions of women by educators, their peers, employers, and general society, play a large role in the way that women perceive their own abilities; if they are seen as inferior, they will inevitably see themselves this way as well.It is important to note as well, that this experience is also applicable to those students of racial minorities, regardless of gender, and that therefore biases towards black women are often greater than those for other female members of the class (Riegle-Crumb and Humphries 291). It is probable that the received story of science, then, will be doubly likely to omit the roles of women of colour, and such omissions may be all-the-more trenchant for also failing to appreciate a) that science is not limited to conventional 'scientific' spaces such the laboratory environment, and b) the collaborative nature of much scientific research, rather than continuing to valorise the Lone Male Achiever.

ii.) Teaching Science Without Human Context

Another factor that may play a role in women's perceptions of the sciences could lie within the way the subject continues to be taught. Michael P. Clough suggests women opt out of science due to a misunderstanding about what science is and what scientists actually do (1). Shelia Tobias agrees, noting that many children (of all genders) seem to have "mistaken notions" about what science is, due to the way that they are exposed to it during school, and they therefore lack the ability – due to failures in the teaching of science – to comprehend abstract scientific concepts. This is consequently associated with a decreased imaginative capacity to see themselves, as human beings, working in scientific fields (Clough "The Story" 1; Tobias

81). Much of what pupils are exposed to shows science as "a rhetoric of conclusions," removing the scientist's role in the discovery and showing only the facts as they are (Clough "The Story" 2). Without human context there is a lack of understanding in terms of what humans in science do on a day to day basis. Students are learning about 'products' – the discoveries that have been made, but often not about the 'processes' and the people – who made those discoveries, and how they did so. Textbooks seem to have the singular focus of showing the facts without any context given in the form of a scientist figure, any historical or era-specific context, or even, sometimes, the methods by which the scientists came to their conclusions (Clough "The Story" 2). Students have reported this lack of information often when asked why they dropped scientific subjects in tertiary study. Shelia Tobias notes in 1990 that students on track to major in STEM subjects became "disenchanted" with the subject, stating that they were disappointed with the lack of information about "*how* the various methods they were learning had come to be, *why* physicists and chemists understand nature the way they do, and *what* were the *connections* between what they were leaning and the larger world" (Tobias 81, original emphasis). With the research and pedagogy removing human agency from the conversation about science, it becomes increasingly likely that young people (particularly women, given culture's additional barriers to girls' STEM access) are unable to see the need for humans within the subject and therefore cannot envisage themselves in the field in the future.

This is both a global and a local issue. In the global context we have seen some influential male scientific figures who are household names; think Albert Einstein and Stephen Hawking. Western science has a multitude of these figures throughout history, known via the popular media or learned of in books. Yet scientific teaching still lacks a modern engagement with those figures who are a key part of the current field of science and their role in the discoveries being made, and when attention does happen to be given, it almost always falls on men. When

attention is given to women in science, this occurs as a *corrective* to the habituated norms, and the paradox remains that in addressing the absence of women, this 'special attention' *also* of necessity concedes habituated lack, the special exceptional category perhaps further distancing women from the public visual representation of science and implying the almost impossible heights, for women, of careers in science. The lack of information about who scientists are not only stops pupils from being able to engage with the sciences in a relatable way, but also removes the possibility for young people to be exposed to "positive and realistic role models" (Schmidt and Nixon, 256). By creating a different, more innovative approach in the sciences, drawing on literary methods such as narrative and character, we could be exposing young people to the world of science and other STEM subjects that, despite the appearance of being technological and fact based, is dependent on the humans who do the research.

The problem with the dehumanised modern discourse of science differs from the public representation of scientific disciplines in the past, where scientists were well known and often widely respected, and were closely associated with the scientific concepts they originated. We know of their lives, their motivations, and their achievements, all of which allows them to materialise in our imaginations *as people*, and perhaps to become role models for young students. Here, in the process of life storying, clinical scientism is embodied and vitally animated in the figure of 'the person'. The bare facts given in textbooks and the dispassionate methodology which characterises scientific experiments as occurring virtually without scientists paint the STEM fields as a place where knowledge is stored, not where things happen or where people act and fail and succeed, working through trial and error. If one does not see a place in science for human activity in general and then one takes into account the fact that women are already excluded from scientific discourses, either by internalised sciencephobia or via the stereotypes put firmly in place by others which lead girls to suspect that their 'lesser'

intelligence does not allow them access to male-dominated scientific fields, it is not difficult to see why young women might not imagine any place for themselves in science. Additionally, in South Africa, and Africa as a whole, there is a dearth of famous past scientific figures, with Western celebrities and successful cultural figures taking centre stage over local figures for many people. In my view, we should be working harder to humanise the contributions of African people in modern scientific fields and highlight the names of those playing a role today. Think Francisca Nneka Okeke, a Professor of Physics at the University of Nigeria who won the L'Oreal-UNESCO for Women in Science Award (2013) for her work on climate change. And Dr Julie Makani, a Tanzanian researcher whose work on anaemia and sickle cell disease has made incredible contributions to the field of biomedical science. And Quarraisha Abdool Karim, a South African epidemiologist who has made important contributions in understanding the HIV epidemic as well as advising on the 2020 COVID-19 pandemic.

In terms of women's lack of representation in the scientific community, there is evidence to suggest that the perception of science as a negative environment for women and the concomitant lack of female role models, may be turning away women before they even consider a career in any scientific discipline. It has been suggested that perhaps the persistent emphasis on the negative side of being a woman in STEM fields may be doing more harm than good (Etzkowitz et al. 13). Though it is important not to hide the problems or sugarcoat the challenges that women may face in electing to pursue the study of science, by only showing the negative gender barriers that women face in scientific careers (such as sexual harassment, exclusion from promotions or leadership opportunities based on gender, and rejection by their male peers for intruding on a perceived male-only field) we are persistently portraying a workspace that few women would ever *want* to enter. Therefore, it is important to show the positive as well, particularly with the inclusion of female role models who demonstrate to

prospective female scientists that it is possible to succeed in scientific careers (Etzkowitz et al. 13).

iii.) The Visibility of Women in Science in Popular Culture and Society

As mentioned above, without successful, relatable, and visible human figures students can become disillusioned about where they actually see themselves progressing within a field. Other career choices in our modern technological age have much more visible role models and success stories. If we can compare how scientific figures in the past were perceived in their time to where scientists are today there is a strange disparity. In the past, scientists such as Isaac Newton, Charles Darwin, and Albert Einstein were very well known in their day, considered household names, famous in their own right. Today, our idea of who is famous has shifted from those figures at the forefront of scientific discovery to new jobs that did not exist before; consider the visibility of YouTubers, viral TikTok stars, and reality television personalities. In contrast to how well-known celebrities are, it is often the case that the average person cannot name a living scientist (Lew). However, there is the potential for an individual to become a well-known and well-respected scientific role model if one considers the global nature of social media and its ability to spread information and stories about individual lives. As a start, scientist David Steen started a social media movement using the hashtag #actuallivingscientist, designed to humanise scientists for the general public and reveal how many exist in the world (Lew). A similar move was made by female scientists using the hashtag #womaninscience which was designed to give women more visibility in a field in which they remain a significant minority. This is an important part of the conversation, because while scientists in general are often faceless to the general public, the few who become famous in recent times are almost always men; for example, Neil deGrasse Tyson, Bill Nye, David Attenborough, Elon Musk (Biba). With representation online and in the media women could highlight the problems in their fields

and young women could grow up with strong female role models through which they could visualise their own potential successes as tangible and achievable (Etzkowitz et al. 13). This is not to say that there are no potential role models for women; there are many female scientists who have in the past achieved and are in the present achieving great things in their fields. The problem is in their visibility to the general public. It is also important to note here that my use of the word 'woman' is a generalisation. For black women and women of colour, the inequality in the field of science (not to mention other areas of society) is far greater and more invidious than for white women. Research by Ebony McGee and Lydia Bentley, for instance, examines the experiences of "high-achieving Black undergraduate and graduate women in science, technology, engineering, and mathematics (STEM)", and their "findings reveal that structural racism, sexism, and race-gender bias were salient in the women's STEM settings. These experiences were sources of strain, which the women dealt with in ways that demonstrate both resilience and trauma" (265). In my present study I am addressing the general sexism faced by women as a whole, but the disparities for women become increasingly complex and the gap in equality widens greatly when the inequities of race are taken into account. See for example Diann Jordan's *Sisters in Science: Conversations with Black Women Scientists about Race, Gender, and Their Passion for Science* (2007).

When speaking of women's habitually invisibilised places in the domains of science, it is also important to extrapolate to the way they are represented in popular fiction where science and literature overlap. When looking at pure science fiction, as well as fiction that also includes science, women are rarely portrayed as intelligent and successful figures. (Granted, this is something that is under contemporary pressure to change, with more television shows and movies portraying women as leading scientists, mathematicians, and engineers. Consider for example Dr Louise Banks, a linguist, in 2016 film *Arrival* and Shuri, an accomplished scientist

in the Marvel movies *Black Panther* (2018) and *Avengers: Endgame* (2019).) Oddly enough, in older science fiction movies, such as those of the 1950s, women *are* (somewhat uncharacteristically for the time) shown as serious scientists: Dr Lesley Joyce in *It Came From Beneath the Sea* (1955), for example, portrays a marine biologist and Dr Ruth Adams, a nuclear physicist, in *The Island Earth* (1955) (Merrick 751). While this might suggest a changing view on women and their scientific abilities it has to be said that the one significant similarity between all of the women portrayed as scientists was their overtly emphasised physical attractiveness and, often, their place as a romantic interest rather than as a knowledge contributor to the science taking place (751). Helen Merrick also notes another problem one can take from the representation of women in these kinds of films: that the image of women and men working in harmony in scientific environments does not represent in any way the reality of the situation, choosing not to acknowledge the material barriers that women face in working in scientific disciplines and fields (752). While the legal status of women in schooling, workplaces, and society has improved, the cultural view of women as unequal in scientific ability is still in place in popular culture and retains a grip on the views of friends, family and educators (Merrick 746).

Jocelyn Steinke, a professor of science communication whose work focuses on the influence of the representation of women scientists in media, conducted several studies into the representation of women in science in the media and the impact that this has had on women's perception of themselves and science. In a study completed in 2005, she investigated 23 films made between 1991 and 2001, analysing the female scientists depicted in them and how they were being represented in terms of "appearance; characterisation; expertise, ability, and authority; work versus romance; and work and family life balance" (Steinke "Reinforcing" 38). Steinke concluded that though representations of women that were overly gendered have

improved, decreasing in comparison to previous decades, there are *still* elements of gender-based stereotyping that appear in today's popular fiction (Merrick 752). As I indicated above, she notes that though women are now more likely to be shown in higher ranking positions and are shown as more intelligent and confident, they are habitually still shown as incredibly physically attractive and, most significantly, as part of the romantic plot line (Merrick 753). There is rarely a mainstream, popular movie that shows a female scientist who is intelligent *and* capable, and successful women are marred by a flaw of some kind. These women tend to be shown as unattractive (until the inevitable makeover that makes them desirable), or too busy with their children to perform professionally in their job, or too emotional to lead a serious scientific research project. The damage that can be caused by constant representation of women in this way (the representation, of course, not being limited merely to science-based careers) is that women are seldom seen as assets to a company or as intelligent human beings in their own right. This might suggest partially why women are treated in diminished ways, by themselves and others. Women might well view movies that provide what appear to be a feminist role model in a scientific career, but the message they are receiving in the filmic narrative is more focussed on image and eventual love interest, rather than women's careers. Men may watch these movies and see women as attractive objects in the lab, destined to be a part of a romantic encounter.

Advancing Women in Science

When attempting to create a feminist narrative within the sciences we are asked to think inventively about finding "new and more appropriate ways of knowing the world" (Longino 101). In this part of my MA, I am attempting to do something along those very lines. In *Athena Unbound: The Advancement of Women in Science and Technology* the authors discuss an idea for encouraging more women to embrace science as a career path that is available to them.

They posit that by only exposing the negative sides of being a woman in STEM fields or only presenting the "picture of ... resistance" that women will invariably encounter if they enter scientific fields, research may be doing more damage than good (Etzkowitz et al. 13). Of course a feminist-inflected reviewing of the story of science should not deny or occlude the challenges, for girls and young women, of what it might entail to work in STEM fields. But to turn the lens slightly: there might also be value in discovering a means to combine persistent difficulty with a more positive, inspirational message. Presenting girls and young women with successful female role models who have succeeded in science can help them to see their own success as tangible, achievable (Etzkowitz et al. 13). My intention, in writing short stories based on female scientists who succeeded in their fields is to develop a small repertoire of just such role models for agency, both imaginative and material.

While the concept of a positive role model as a method for feminist change was important to first wave feminism, there has been a resurgence in this method in recent years. In 2018, a study from the Women's Media Center found that 63% of girls aged between 10 and 19 felt that there were not enough female role models for them to look up to (Women's Media Center 7). I believe that in uncovering (even inventively reconstituting) the neglected and marginalised stories of women in science who have succeeded in the past and those who are succeeding now, and creatively depicting these narratives in the form of short fiction, it may be possible to open the door for more young women to see that their negative assumptions about their scientific ability and their hostile perceptions of STEM fields, may be unfounded. Of course I appreciate that there is no direct correlation between such innovative re-imagining of female-centred stories of science and the uptake, by girls and young women, of an interest in subjects like maths, life sciences, physics, and chemistry, and in tertiary-level scientific study. Yet literature and popular fiction can play a role in helping young people to understand the world. Exposure to careers, in any field, as well as to influential historical figures, provides an insight into what

a prospective future might look like in choosing a career path. It also begins to change the conversation, moving away from only showing women the problems and obstacles related to being female in the field of science and providing positive insight into women's belief in their own abilities, and the joys and satisfactions they have experienced from scientific work (Etzkowitz et al. 13). Fiction, in its many forms, provides an approachable format through which to view the world, particularly for careers in STEM fields that are not necessarily seen by the general public (particularly children) as easy to comprehend.

In this regard, it is also notable that in recent years there has been a surge in the publication of popular books that focus on the success of women from the past. Consider the success of Katherine Johnson's novel *Hidden Figures* (2016) (and its subsequent film adaptation), which addresses the significant contributions made by black women at NASA in the 1960s whose stories were never told. Also, consider children's book collections such as *Fantastically Great Women Who Changed the World* (2016) by Kate Pankhurst, a volume which tells the stories of several successful women throughout the ages, including Amelia Earhart and Anne Frank. With the growing popularity of such books, starting with informative but accessible storybooks for small children, there is a chance that encountering animating life stories of women in science will begin to change young girls' mindsets about their future options and career choices. I appreciate, here, that there is a large percentage of the world's population that cannot read, that does not have access to adequate education, or will not have access to books such as the one I am attempting. Nevertheless, the intention of my work is to join the larger conversation taking place on the global stage regarding the representation of women in science both throughout history and moving into the present. The larger goal of this conversation is to increase the popular visibility of female scientists and their achievements, and to advocate for and improve the status of women on a global scale. If real change can be made for women the

world over, equalising their status and granting the equal power of their intelligence, hopefully more women will have access to a proper education.

While much has been done recently in terms of the publication and sharing of women's stories from the past, slightly correcting the long historical vacuum of women's representation both in science and in careers beyond the scientific, my concern lies in what is still missing. The contemporary focus on female 'achievers' tends to privilege a clear set of women, whose already-familiar lives almost pre-select them for further focus, in popular publishing: names such as Amelia Earhart, Frida Kahlo, Anne Frank, and Coco Chanel appear over and over again (as in titles such as the above mentioned children's book *Fantastically Great Women Who Changed The World,* as well as Yelena Moroz's *Little Feminist* (2019)). This is a litany which begins to become dogma, and paradoxically *narrows* people's openness to wider life story scope. This is not to say that the contributions of these women to aviation, art, autobiography or fashion have not been noteworthy; only that there are many, many others whose contributions should also be highlighted, but who are invisiblised by neglectful omission due to the publishing industry's restricted optic on what counts as worth publishing, which in turn is linked to beliefs about which lives are most valuable, and which lives might offer publishers a good financial return. This self-fulfilling cycle means that what already *is* believed to be worthwhile then paves the way for ongoing similarity, rather than enabling innovative ways in which to accommodate difference, diversity, outliers. The power of influential men prevails. To extrapolate to the world of science the explanation of Bonang Mohale (a successful South African businessman and academic) made in relation to the dearth of women corporate leaders in business: "The ability of men to confer advantages on other men encourages a fairly high degree of social self-recruitment within privilege from one generation to the next". Because of this, "there often develops a pattern of social and cultural differentiation, which, in turn,

reinforces the system of occupational recruitment and so crystallises the masculine structure through time" (Mohale). Overall, like women more generally, women in science may thus be considered to "still suffer many disadvantages in various areas of social life including employment opportunities, income, property ownership and so forth. This is because, for most women, the allocation of social and economic rewards is still predominantly determined by men" (Mohale).

In such established patterns of preferred attention, there is also a decided lack of representation for women in STEM fields, in particular. According to my research, names such as Marie Curie become dominant common knowledge, while many other names never appear at all or seem relegated to footnotes added later with the intent to make up for their exclusion at the time (Yong "The Women"). It seems that even in narratives designed to show that women can succeed in all fields, women in science are still often given short shrift. In my own small project, by gathering diverse (albeit selected) stories of various women from a variety of STEM fields into one collection of short fiction, I hope to give at least a glimpse of the extensive contributions that female scientists have made to notable scientific discoveries that underpin the workings of the modern world. My re-storying of the lives of women in areas of achievement such as astrophysics, mathematics, and geology, intends to illustrate, through the exciting vividness of combinations of life features such as determined effort, serendipity, and personal discovery, that there are manifold examples of high achieving female scientists that young women can look up to and view as demonstrative examples of their own potential and future success in STEM fields.

Chapter Two - Historical. Short. Archival. Interconnected Fictions

And Other Scientists: Stories of Women in Science is structured as a collection of short stories. Putting aside the advantage of a collection of pieces instead of a singular story, allowing for the inclusion of multiple stories about many women, there are three main reasons why short stories were an important choice for my collection and the building of my creative archive. Firstly, the short story's convenience in fictionalising history; secondly, the larger overarching concept of an archive for women in science, and thirdly, the short story's usefulness in a learning and teaching capacity. In this chapter I will be discussing the above mentioned reasons for choosing short fiction as a medium for creating the collection, continuing to ask the question of how the worlds of literature and science can work together in highlighting women's important place in the scientific community.

Fictionalising History Through Short Stories

Historical fiction is literature based on, or that works with, historical events (Beck et al. 547). It often involves imaginatively drawing on the facts that we have about the time period being explored and will usually attempt to convey a sense of the spirit of the social issues and conditions of that time, often through a vital sense of characterisation. What separates it from historical non-fiction is the ability of historical fiction to creatively interpret how people's lives might have been. While non-fiction seeks to depict with some exactitude the reality of 'what happened', based on the writings of the time and anthropological research into the era, historical fiction allows authors to creatively fill in the gaps of history, making "the lives of other people … more accessible, thereby contributing to our understanding of human nature,

universal truths, and historical patterns" (Beck et al. 547). Via an author's presenting facts through the eyes of an historical figure or an invented character, the reader can gain a sense of what life might have been in the past (although the details may not be entirely based in facts). The advantages of historical fiction here are that while we can read an academic piece on a time period, we cannot always identify with people from other time periods in this manner - thereby, perhaps, not gaining an accurate understanding of what life what like in that time. By humanising the past through the eyes of a character (whether real or invented) the reader is given the potential ability to experience life from that person's imagined point of view. As Karen Cushman, author of *The Midwife's Apprentice* (1991) (a Newbery Award-winning historical novel) notes, historical fiction brings "a sense of the everyday life of what it was like to live at that time. Of how … bigger issues played out in individual lives" (Cushman qt. in Beck et al. 547). By using the term 'humanising' here I intend the meaning of relatable; in that literature can be a way in which to see into others' lives and find identifiable links to one's own life, thereby allowing the reader to feel a connection or an emotional kinship with the person, situation and events in the narrative even if the reader's own lived context is not directly related. Historical fiction helps us to understand the similarities and differences between our modern lives and those of the past – an important part of historical research. Writing facts into a narrative therefore allows for readers without extensive historical knowledge of the time or place to understand what life was like without a reader experiencing the flattened, dogmatic sense of reading a textbook. This is useful because most people generally understand how narratives work, they "follow a particular structure" and are used to explain events and the impact that they have to characters over a specific time period (Dahlstrom 13614). As they are understood in a certain way, such narrative structures can be applied not just to fiction, but also to historical events, scientific discoveries, and case studies (to name just a few forms); and in general people will be able to understand the information discussed as the format is familiar

(Dahlstrom 13614). I will be exploring the significance of this in the section below, as I believe this plays an important role when we look at short stories as a medium for teaching and learning, not just in their capacity to be a type of entertainment that also 'happens' to involve facts.

Historical fiction, whether longform or short story, is still something of a contested genre. As Wallace remarks: "Despite what often seems like our current obsession with history, historical fiction in general still occupies a surprisingly marginal place in the literary canon and the academic curriculum" (206). While an "important turning point in the respectability of the genre seems to have been 2009 when the Man Booker Prize was won by Hilary Mantel's *Wolf Hall* (2009), from a shortlist in which five out of six novels were historical" in the same year "the historian David Starkey lambasted what he called 'the quasi-history of historical novels, written by women, about women and for an overwhelmingly female readership' as mostly 'tosh'" (cited in Wallace 206). Given such derisive comments about the gendered nature of the genre of historical fiction – all that female emotion and ahistorical imaginative embellishment and out-of-time incredulity – perhaps this becomes another persuasive element in my choosing to write short stories of historical fiction about the lives of marginalised women of science. As Wallace indicates, historical fiction is well-placed to create a space for the representation of "difficulties, discontinuities and differences" in the lives of women and the cultures in which these lives are lived. Additionally, as current scholarship is indicating, 'historical fiction' deals not only with the past, as something in the far gone realms of time, but also with the ramifications of the past for the present, where the very scope of historiography and how history is understood may become meta elements of the conception and writing of a piece of historical fiction. Siân Harris's research is helpful here. She emphasises that women's writing of historical fiction may entail a turn to "critical

theories…almost invariably accompanied by a sense of instability and doubt. Thus, when exploring the complexities of the relationships between women, history and fiction" – for example in the historical fictions of A.S. Byatt and Marina Warner – a reader "encounters not only sites of contact, but also sites of confusion. The boundaries between the past and the present, history and fiction, text and truth, are blurred, and the process of their negotiation is a constantly evolving dynamic" (171). In writing my own short stories of the marginalised women of science, I have been intrigued by Harris's discussion of the methods used by writers such as Byatt and Warner. She explains that they initiate three key methods: "the imaginative manipulation of history to provide a context for their narratives", "the investigation of history to provide content", and "how this could constitute an intervention with history" – feminist and metafictional – "disrupting the past while offering an enhanced understanding of the present" (Harris 171). This seems an appropriate series of moves for my own project.

Now that we have established an impression of what historical fiction is and how it may morph in its use, it is important to ask why *short* historical fiction? In the sub-genres of popular fiction, historical novels are not uncommon, with many becoming internationally popular, among them Philippa Gregory's *The Other Boleyn Girl* (2001) or Hilary Mantel's bestselling Wolf Hall trilogy, the historical saga imagining the career of Thomas Cromwell in the court of Henry VIII. The historical novel format allows the author to explore relationally a person or person's entire life, or a long period of that life, such as the reign of a king or the time period of a significant war. The length allows for the exploration and development of very detailed relationships, contesting families and networks of genealogies, and years of internal and external conflicts. There is also time, in longform historical fiction, to build a gradual connection between the protagonist and reader. However, short historical fiction provides an

approach different to that of historical fiction, even though I believe there is an element of intersection to be found between historical fiction and short fiction, since both are playing with conventions and experimenting with representations of history and questioning how compressed or expansive a fictional depiction of an historical narrative might be. Is it necessary to write an entire novel on a moment, or a person, or a place, or a time, to have told a compelling story? Surely, a short piece of fiction can do the same job. Yes, the word count will be shorter and there is not the time and space to explore the depths of the world and the relationships within it, but that has added benefits in other ways. As Florence Goyet argues, the length of the genre often overshadows its "evocative strength," as while the reader only experiences a short moment or moments in time, those moments have an "extraordinary vividness," a clarity that is only possible because the moment is not hidden amongst others in a longer piece (74). There is a "balance of abstract and concrete" in short fiction (Goyet 75). 'Lessons' to be told can be alluded to rather than discussed in depth, characters can be explained through "the enumeration of characteristic traits" instead of detailed back stories and long character arcs (Goyet 75). Readers are plunged into a moment, suddenly surrounded by characters they recognise through association to traits they are familiar with, and in a well-written story can comprehend the narrative that unfolds without the need for elaborate context. While longform historical fiction also flirts with what may or may not have been real, perhaps aiming less for fastidious documentary truth than for the emotional truths of reader empathy and identification with a life in time, short stories about historical people and situations can further intensify such effects via compression and selection. They allow a writer more pointed ability to pick at the moments that will be selected for representation, while strategically abandoning those moments you choose to leave out precisely so as to heighten the effect of the focus point. Short stories may also be more amenable to some parts of the general public, particularly the "'reluctant' reader" who may find a piece of short fiction less intimidating than a novel, especially when the content

involves historical or scientific facts (Lent 55). Depending on the subject matter, this brevity can have more of an impact than the gradual unfolding of a novel.

While the novel "patiently constructs more complex truths" and "carefully builds … characters", the compressed length of a short story allows for content to be concise, and for the very aesthetic to reinforce a quick sharing of a story in a distilled form (Goyet 78). For example, my story on astrophysicist Cecelia Payne-Gaposchkin tells only a few moments of her life as a scientist. Her life, as a whole, was successful and expansive. Her achievements in the field of astronomy go far beyond the scope of the short story I have chosen to write, but for what I hope to achieve with this particular piece, and for the collection, the rest of her life is not of consequence. It would have been possible to write a novel on her life, which her daughter Katherine Haramundanis did in 1996, but for creating a small revisionist archive of stories of women in science the moments that are detailed symbolise a much larger story. The moments in which she made the discovery that the elements which comprise stellar bodies were vastly different to what was previously thought were incredibly important for her life and for science as a whole (Greenstein 440). However, what is also key is the aftermath of this discovery, with men in her field insisting that her research could not possibly be true (Horn 1354). This damaging legacy, not generally foregrounded in the history of science, is just as important to the overall storying of the archive in which my MA research engages. While the greater, overarching story of this archive is designed to highlight the plain fact that women scientists tend to have been left out of history – the implication that their entire life stories deserve to be known, and told – even my inventive telling of selected important life moments shows how or why they may have been excluded from the traditional archive. For example, Cecilia Payne-Gasposchkin undertook severe self-censorship to avoid making other scientists uncomfortable, and my featuring of such erasures and silences and hesitations in a story on this female scientist

emphasises the powerful point that this archive need not wait for the slow uncovering of history and historiography, or for a reader gradually to acquire a deeply factual knowledge of the female protagonist's life, but that short fiction has an imaginative capacity to animate and to 'deliver' the lives of the missing women of science in an emotionally affective, concise way. (The concept of an archive that I have mentioned here will be discussed in the upcoming section.) Instead of exploring the women all individually in great detail, short stories have allowed me to think carefully about their contributions to their fields and how they were treated during their time, and since then. In crafting short stories, I have found that the very form asks you to pinpoint the moments that will make an impact, the moments that say more than what is literally happening in the scene and potentially speak to a greater issue without the deadening effect of political preaching. In my collection, this issue is the systematic exclusion of female scientists from traditional historical knowledge.

Experimenting with Archives and Form

Why an archive? Using the word archive to partially describe this thesis project might be seen as a strange choice or even the wrong choice. However, there are several reasons why I believe this project deserves this phrasing in some capacity. It is not an attempt to create an archive as we understand a traditional archive; it is an attempt to experiment with form, genre, and the crossing of fields of study, while creatively compiling innovative emotional-informational stories of female scientists' lives. It is an attempt at a new kind of archive, a small illustrative archive that in this case focuses on women in science.

A traditional archive is, usually, a collection of documents or artefacts that is compiled to organise information from a point in history. An archive is often perceived as "a musty place full of drawers, dim lights, filing cabinets, and shelves overloaded with old documents" a

"place enclosing records, a container of objects … an institution" (Yaneva 22). This process of archival collection, however, is not just a physical archive of information, housed in a building or room or filing cabinet, but is a discursive enterprise that represents part of the past; a specific world view. An archive, then, is also a figurative embodiment of ideology and preferred epistemologies, marked both by assertions, and by gaps. Michael Bernard-Donals explains that Jacques Derrida, the French philosopher who analysed language and texts through a critical-theoretical process he called 'deconstruction', saw the archive as a "dwelling", a place in which words are brought together and protected (Bernard-Donals 704). Though this physical archive might seek to represent the entirety of the period of history represented, as I have already mentioned in my Introduction, the included documents are never the entirety of that time. There are always stories, facts, lives that are omitted, whether consciously or unknowingly. Derrida saw the way that an archive is in stasis as a negative aspect of storing information, as the dwelling that protects information from being lost can also be seen as "the cupboard, the coffin, the prison cell" (Derrida 23). This then entails a curiously generative paradox. In a sense, because we are confining or collating information and writing into one place to be stored, the information that *is* present becomes marked by the absence of everything else that is inevitably missing. Derrida argued that the work stored in an archive serves as not just a representation of what happened in the past but also as an oblique record of the social currents and ideological knowledge practices which might have caused the document to be created in the first place: here, he mentions, for example, the society of the time, the class of the person who wrote it, the political standing of the country. For Derrida, though, the archive does not and could not include events that had not been recorded (Bernard-Donals 705). In relation to disregarded or marginalised women's lives, then, this creates a perplexing anomaly: since such lives are not recorded in The Archive, does this mean that they never occurred? Of course not. Thus it becomes necessary to shift our conception of archival thinking and practice precisely towards

how and why to accommodate the omissions. It is such missing or overlooked elements that drive my own creative project. For as Derrida goes on to observe, such occluded lives and events "deserve a place in the archive"; they should be a part of the collection that represents the time, even though there is no physical representation of them (705). Derrida grants the incongruity that the absence of these events, people, objects, cultures, stories, from the traditional archives leaves a trace of the fact that they are missing *in* the fact that they are missing. There are spaces, gaps, in the archive where stories should be, and their absence is perhaps more telling than their mention or their inclusion would have been.

Therefore, it is important to appreciate that I am not attempting to create another kind of traditional archive, an imitative 'new' archive that merely resembles that which already exists. Perversely, to create an archive of what has been left out only creates more spaces. There are always excluded parties and stories. However, I am looking to create an innovative take on the concept and practice of 'archive', an agency on my part which asks us to concede the impossibility and indeed the undesirability of privileging The Archive that has been bequeathed to us by conventional History and historiography. Of course, I am by no means the first to attempt new representations of history, stories, and events in the service of a female-centric archiving. Nupur Chaudhauri, Sherry J. Katz, and Mary Elizabeth Perry, editors of *Contesting Archives: Finding Women In the Sources*, are just one example of the attempts made to highlight the fact that women are consistently left out of historical archives and narratives because of the "lack of archival trace" that would give them the handholds to survive time passing them by and excluding their names from history (Chaudhauri et al. vii). Even beyond the ambit of habituated historical discourse, however, I intend my creative MA project to be an experiment, combining forms and styles and stories and eras in an attempt to add to the growing archives being created for groups excluded in the traditional archives. As Wendy Duff

and Verne Harris note, an archive "reflect[s] the values of the archivists who create them" (Fintland 139). They suggest that users of archives should consider the "worldview" of the creators of archives, exposing and clearly laying out "their assumptions, their biases, and their interpretations" as this plays an integral role in the future interpretations of the archive by readers (Fintland 139). As Derrida adds, the archive confronts us with history, with past memory, with previous opinions, and future possibilities; it can arouse in us the compulsion to write further, to ask questions about the past (whether this past is recorded in the archive or mysteriously absent, as but a spectral trace) and to think of the potential futures that might occur and that might make us want to archive these events (Bernard-Donals 706). Therefore, in the case of my creative thesis it is not just about the inclusion of stories of female scientists whose names have been erased or overshadowed in favour of men's, it is about engaging with the missing parts of the traditional archives (from which women have been excluded and in terms of which women also embody such missing) as well as the scientific community (and the world at large) which is presented as a female-inclusive environment but still lacks gender equality.

In the use of short fiction as a form for creating this contribution to a growing women's archive, short stories become a way in which to weave women's largely ignored contributions to science into an approachable social story, using a moment or moments in a woman's life and thereby creating a space for the discussion of women who were excluded while facilitating a discussion about women in science in the past and presence that is understandable to the general public and scientists alike. The aim is for a reader to encounter intriguing figures of female success in various fields (and eras) of science, and to understand their contribution to scientific advancement without needing to be overwhelmed by arcane or erudite scientific terminology or longwinded discursive explanation. The short story combined with the concept of archival

writing also allows for exceptional creativity and even experimentation when it comes to format, something that I have used in combination with the variety, differences and particular life story elements informing the experiences of the women in science on whom I have chosen to focus. Rosalind Franklin. Mary Anning. Gita Ramjee. These women lived different lives, in different time periods, and dealt with varying subject matter in their research. Some were encouraged and some had to fight for recognition; some made massive advances in their field, such as Rosalind Franklin's role in the discovery of the shape of DNA, and others made an impact in the society around them, such as Wangari Maathai's influence on environmental issues and the lives of the women in her community. While for the most part I adopt a familiar treatment of the short story, imaginatively recreating aspects of a character's life, at other times, working in a format where traditional rules regarding formatting and layout are temporarily suspended, I attempt to be more experimental, hoping to highlight the ways in which women scientists often had to change the way that their fields worked in order to unsettle received ideas and invent new means of scientific discovery. The women on whom my short fiction focusses had thought processes which were unique and forward-thinking and they did not unquestioningly subscribe to the norms that governed their fields. Sometimes this occurred by virtue of the simple fact that they existed as *female* scientists, in areas of enquiry such as astrophysics or mathematics or physics, whose androcentric traditions gave little credence to the possibilities of women as scholarly experts. I hope that by experimenting with the form of fiction, incorporating sections of laboratory notes, fictionalised abstracts for scientific papers, and GPS commands, to name a few textual devices, I can represent in *fiction* these women's involvement in *science* in a way that is aesthetically and formally suggestive of their experimentations and research work.

Using Short Fiction in a Learning and Teaching Capacity in the Sciences

The previous section has addressed why my creative thesis engages with the writing of short stories, and why short fiction was a decisive choice for this project. The present section intends to discuss another side of short fiction, in its relation to the sciences in a learning and teaching capacity and how the sciences and literature can overlap. While this may not necessarily appear immediately important in that a collection of stories is for entertainment, for pleasure, for reading, not learning; the nature of an archive is to store and arrange facts and knowledge. Knowledge is distilled through learning, whether by an individual or by a teacher-figure. A social science archive on women in STEM fields is a strange bridge between two usually-opposed fields of knowledge. Scholars in the sciences often consider the stories and storytelling of the humanities to be unnecessary, baseless, indulgent fantasies of life and imaginaries; not useful in any capacity (Dahlstrom 13614). However, there is mounting evidence to suggest that the two fields could benefit from crossovers of knowledge and forms of expression. I believe that the divide between the humanities and science is a rift that lies closely aligned with the issues I have covered earlier in this critical component of the MA; the exclusion of women from science, the excision of women from historical records, the pushing of women to the supposedly 'soft' human science disciplines, and the view that the humanities are somehow inferior to science. These elements are linked. I think that it is important to address the divide and see ways of connecting the two fields for the betterment of both.

Before addressing a study that shows the potentials of a combination of the two disciplines, it is possible to imagine the ways in which both sides shape the mental states of students (who will become adults with opinions on gender, feminism, and science), particularly if there was not the perceived divide between the two fields that persists today. On campuses across the world social science students are often considered lesser students, taking 'easy' subjects, for 'easy' marks, whereas students in science faculties are *allowed* to complain about their

workload, as they are perceived as smarter and dealing with subjects that are harder to understand. However, when it comes to writing academic papers or understanding the human-ness of a scientific achievement, it is possible to think that students of science may be at a disadvantage. This is where the links between the two fields of the arts and the sciences may become important.

Michael P. Clough discusses one instance where the fields of science and literature might intersect and benefit from one another, in "The Story Behind Science: Bringing Science and Scientists to Life", a 2007 study carried out under the aegis of the United States National Science Foundation (NSF) (Clough "The Story" 5). This project was designed to "humanise science" and teach the concepts of the Nature of Science (NOS) in order to "improve science literacy", as well as to encourage more people to pursue science careers (Clough "The Story" 5). The project involved the creation of "science stories" that relayed scientific ideas and facts as well as the lives and thought processes of scientists. Thirty stories were created overall, in scientific sub-fields such as astronomy, biology, chemistry, geology, and physics (Clough "The Story" 7). These stories were distributed to students in tertiary education to see if reading about science in a story-based manner would allow students to better understand their field, in contrast to the facts they received from textbooks. As I understand it, the reasoning behind this project is more than wanting to improve the humanisation of existing science; the project ambitiously seeks to make visible and to 'rebuild' a level of humanisation that has been lost to the way in which science is taught (as will be discussed below).

Researchers have noted that students moving from secondary to tertiary education often report a disappointment in the way in which science is taught (Clough "The Story" 6). Sheila Tobias interviewed students and found that they were "disenchanted" with science, at least in part

because the sciences were taught without the inclusion of the "historical, philosophical, and sociological foundations of science" (Clough "The Story" 6). She notes that the students wanted to know more about "*how* the methods they were learning had come to be, *why* physicists and chemists understand nature the way they do, and *what* were the *connections* between what they were learning and the larger world." (Tobias 81). Clough argues that the learning of bare facts without human context (such as the lives of scientists, the historical context, the biases of the era etc.) that helped to create them can have negative effects on "general scientific literacy" and may be a factor in student's choices to pursue other careers instead of science (3). Several researchers suggest that by teaching science through a "historical approach," involving science stories and historical context, it is possible to convey to students the reality of science with an attractive degree of lived complexity (Clough "The Story" 3). It allows students to see both the "enjoyment and frustrations" of research, the "complexities and challenges" that are faced by scientists in their field, and can help to show science's influence on the wider world in a human context (Clough "The Story" 3).

The stories that would be included in this style of teaching are designed to humanise the subject, the scientist in question or the field of study. Don Metz et al. suggest that by raising the "personal, ethical, sociological, philosophical, and political concerns" of the scientist in question, students have the ability to associate themselves with this person, even if they do not agree with the personal opinions of the scientist (314). As humans, we tend to learn through our past experiences and our observations of others, so if students are presented with a human who has past experiences that they can grasp onto they are more likely to not just understand the concept, but also remember it (Clough "The Story" 4). As Metz et al. note, students remember stories (315). Consider the stories (however apocryphal or mythologised) you might remember about science from your childhood: Archimedes getting into a bath and shouting

‘Eureka!’ as he discovered how to imagine a calculation via how his body displaced water, or Isaac Newton taking a nap and having an apple land on his head and discovering gravity. Though you might not have continued with scientific study, the stories surrounding great discoveries remain with you and are considered common knowledge to many people (Metz et al. 315). This is just one example of how much of an impact stories can have on our ability to retain information. The above mentioned study from the NSF reached a similar conclusion with the dissemination of science stories. In 2007 an introductory geology class was provided with four stories based on continental drift and the age of the Earth (Clough “The Story” 12). The stories were given to students in conjunction with questions on the scientific facts spoken about in the stories themselves, to see if the students could understand the concepts through the stories alone. The students reported afterwards that they better understood that scientific knowledge is not something that is merely “discovered”, but that there is an important process of creativity and invention involved (Clough “The Story” 12). They also understood that scientists and their work represent “the broader culture and society of the time” and that the outside world has an influence on what studies are done (Clough “The Story” 12).

This study is just one example of how a relationship with literature might benefit the field of science, particularly at a student level. The path to opening doors for women in science and encouraging more women to enter scientific fields starts in childhood; and by making science, even in a small way, a more approachable subject for men and women it may encourage more people to choose scientific fields. In humanising science for all, particularly highlighting stories of women and marginalised groups, we can show that women are a normal part of science, equal to men. All of this can assist in changing the perceptions about who scientists are, who can do science, and that women, who are not traditionally seen as capable in scientific fields, can and should be seen as equals in STEM fields. That said, given my own location in a

department of English literary-cultural studies, working towards an MA that has a creative component, I am also dissatisfied with elements of work such as Clough's, and in the subsequent section I expand on this.

It is certainly valuable that scholars in the sciences are interested in what Roach and Wanderson call "short story science" in an attempt to use "historical vignettes as a teaching tool" (18). Such a tool could help "students understand that science is not a fixed body of knowledge but a continuous, dynamic process of human searching for answers often over a very long period of time", encouraging them to "make connections between the past and the present" (18). Yet there might be some trouble in merely conflating "historical vignettes" with "short stories", as occurs in the above study, for there is no recognition that short fiction, too, is a series of skills and practices that is not synonymous with History. Similarly, if we return to the work of notable science educators interested in exploring narrative pathways into the teaching of the Nature of Science, it becomes clear that even those who advocate for the use of short stories in science classrooms tend to have a somewhat narrow conception of what a 'short story' is, or might be. As an example, let us take Clough and Olson's 'short story' about Crick and Watson and the discovery of the structure of DNA. Of necessity, I quote at length what the authors term "Three excerpts from an historical short story":

> In the 1940s, most scientists thought that the genetic material would be made up of protein. Several reasons supported this contention…However, work by Avery, MacLeod, and McCarty in 1944 was interpreted by many scientists to mean that deoxyribonucleic acid (DNA), not protein, was the genetic material. . . Not all scientists agreed with this interpretation of the evidence: Of course there were scientists who thought the evidence favoring DNA was inconclusive and preferred to believe that

genes were protein molecules. Francis (Crick) however, did not worry about these skeptics. Many were cantankerous fools who unfailingly backed the wrong horses. One could not be a successful scientist without realizing that, in contrast to the popular conceptions supported by newspapers and mothers of scientists, a goodly number of scientists are not only narrow-minded and dull, but also just stupid. (Watson 1968, 13). However, Watson admitted that further experimental work was needed to show that all genes are composed of DNA. Additional evidence for DNA being the genetic material was reported by Hershey and Chase in 1952…However, Watson and Crick (and other scientists) were already engaged in efforts to determine the structure of DNA before this work was reported, confident it was the genetic material…Watson spent considerable time trying to make a like-with-like (i.e., cytosine paired with cytosine, guanine with guanine, thymine with thymine, and adenine with adenine) double stranded DNA structure work. However, he acknowledged that the difference in sizes between the pyrimidines and purines meant the sugar phosphate backbone would be quite irregular in width. Crick also noted that Watson's like-with-like idea did not account for Chargaff's rule (the amount of adenine in an organism equals the amount of thymine, and the amount of cytosine equals the amount of guanine). Interestingly, Watson professed not to have much faith in Chargaff's experimental work (Watson 1968, 112). Although Watson continued to work with his like-with-like idea, he eventually began entertaining other possibilities. Later, while trying different arrangements of the purine and pyrimidine base pairs, Watson became aware that an adenine-thymine pair was identical in shape to a guanine-cytosine pair. He writes, "my morale skyrocketed, for I suspected that we now had the answer to the riddle of why the number of purine residues exactly equaled the number of pyrimidine residues.

> Chargaff's rule then suddenly stood out as a consequence of a double-helical structure for DNA" (Watson 1968, 114)". (Clough and Olson 30).

This is (dare I say) quite a dry read. In terms of supposed 'short storyness', the piece falls dramatically short, and reads as little more than a cobbled-together narrative summary of facts, terms, and laboratory moments. It is two-dimensional, plods along the familiar fact line, and scarcely ventures into the interior spaces of mind or heart, playing it safe by toeing the line of the historical record. Such precise storying, albeit narrative-based and drawing on elements of life story, does no justice to the craft and possibilities of short fiction as a genre, which as mentioned before is a genre that allows for creativity and vivid moments that draw the reader into a relatable and understandable world (Goyet 74).

Joanne Olson and Michael Clough are among the most well-known science educators who argue for the use of "short science stories" in the teaching of science, and their team of "[s]cience educators, scientists, and historians of science at Iowa State University are working together to create these historical science short stories" (Olson et al. 4). Their collaborative goal has been to see that "Short stories were jointly developed by two historians of science, a science educator, and the course instructor", so as to "ensure … that the history of science was accurate, the pedagogy was appropriate, and the science content was accurate and aligned to course objectives" (Olson et al. 4). They explain that the "short stories were 5-6 typewritten pages in length and included original words of scientists as well as narrative," and that "these short stories were written to convey specific nature of science concepts rather than simply tell the story of a scientist's life or describe a groundbreaking experiment as is commonly found in textbooks" (Olson et al. 4). It is clear, then, that there is no neat fit between the understandings of science teachers and creative writers-cum-literary scholars about 'the nature' of something that might be considered 'the short story'.

While the purpose-written pieces referred to above may well have uses in the science classroom, they run the obvious risk of merely mimicking fact-based positivistic ideas of science. Part of the problem, I think, is that they are designed to reinforce facts, to enable students to memorise and master supposedly factual scientific terms *even as* they *at the same time* wish to call these into question, so as to uncover the reality that scientific discourse is shaped through context and ideology, through preferred inclusion and experiential bias. In work on short stories for use in the Geology classroom, Olson, Clough, Bruxvoort and Vanderlinden argue that since "short science stories are a crucial way for teaching about the nature of science, they must be carefully crafted and implemented with the following guidelines". For example, the emphasis for Olson et al. falls on the need to create a "tight link…between the fundamental science content and targeted nature of science ideas in the short stories" (3). This might lead to an over-emphasis on facts, at the expense of narrative power, effect and the elusive truths of emotional impact and affect. The assumption seems to be – mistaken, in my opinion – that elements of emotional intensity and character development are merely secondary features of a good short story. Even where Olson et al. do assert that where possible "the voice of scientists should be used to provide authenticity to the nature of science point being emphasized", they do not seem to appreciate that 'voice', in the expressly creative treatment of short stories, entails far more than simply citing historical instances of scientists' views or comments on their science practices (3). The way in which short stories are envisaged by Olson et al. appears deliberately to avoid interiority, character development, emotional depth and even imaginative speculative, so as to stay close to the received truths. However, the opposite problem can also arise in what Douglas Allchin refers to as the "myth-conceptions" of science (330). When an effort is made to add the emotional depth so lacking from the stories in these studies, which science educators (in Allchin's opinion) occasionally attempt to do,

there is a risk of "rendering science in a mythic form", creating a false narrative that science happens in a particular almost magical way (330). Allchin discusses the example of Gregor Mendel, a man whose work with pea plants and genetics is known to most undergraduate students (331). His scientific work, when told in story form, creates an ideal scientific narrative; a man who worked alone, "seek[ing] truth, not ambition", who stumbled upon an incredible scientific discovery, but went unrecognised in his time (Allchin 331). His story serves as the ultimate example of the ideal narrative of science, that "Scientists do not err" (331). This presents a narrative in extreme opposition to the flat, unemotional story presented by Clough and Olson above; on one side a thinly veiled mass of facts and on the other a "Greek tragedy … dramatizing the consequences of *historical* hubris (forsaking humility in professing knowledge of history of science)" (Allchin 331 original emphasis). My own short stories, while still the work of a writer finding her voice, attempt to offer a more innovatively imaginative treatment of history, by venturing into the realms more familiar to readers of historical fiction.

Even Clough's most current research paper again seeks to make the case for using what he calls stories to shift the way in which "science textbooks frame what content is taught and how it is taught" (Clough "Using Stories" 513). To this end, so as "to assist teachers in accurately teaching about the history and nature of science" he draws his audience's attention to "a project titled "The Story Behind the Science (https://storybehindthescience.org)" that "has created and made freely available short historical science stories that address the development and acceptance of fundamental science ideas in astronomy, biology, chemistry, geology, and physics. These short stories overtly draw readers' attention to important nature of science ideas and enrich the learning of science content. Research provides evidence that the stories assist in improving students' NOS understanding and attitudes toward science careers" (Clough "Using Stories" 513). However, as my own present chapter has been indicating, my MA project does

not neatly intersect with such an endeavour. Clough's efforts unfortunately fail to understand that literary-creative disciplines have their own, discourse-specific set of imaginative skills and practices through which stories are created, and that a successful 'story' does not equate with knowledge transfer.

My short stories of selected marginalised women of science take a different tactic than those advocated by the scholars whose work I have discussed above. For instance, I work with the lives and the experiences of the women, taking aspects of the historical record and infusing this with interiority, in an attempt to conjure some of the practical, psychological and emotional life scapes that might have typified the gendered (and raced) circumstances of such female scientists. My attention and method in writing the short stories aim to reach beyond the somewhat instrumentalist teaching exercises devised by scholars such as Olson and Clough, precisely because I maintain that short stories, understood as literature and not accumulations of fact and data, are admirably placed to convey the complexities and incongruities of scientific practices: the lack of clarity, the frustrations, the injustices, the inner turmoil and delight; the structural contingencies of the individual in relation to the team and the institution and the spaces beyond the laboratory. Additionally, the kind of short stories of women in science that I am interested in writing depend on my conviction that short fiction can teach about the *lived processes* that may inform science, rather than only the big moment. Here, perhaps, there is a potential overlap between the characteristic scientific method of close observation, although my 'observation' may be a creative mapping, rather than an empirical recording. I am interested as much in the elusive, affective 'evidence' of a woman scientist's feelings, for example, missing from historical accounts or from supposedly impartial science historiography, as I am in the evidence of the scientifically proven experimental method.

Also relevant, I believe, is that despite scientific codes and preferred practices, which insist on one meaning/one term, the connotative language elements of short fiction may work to emphasise for readers (among them teachers and learners) that science is made *in language*; a fact that seems to be forgotten in comparisons between the humanities and sciences. My understanding is that short stories of women in science may have a powerfully unsettling quality. Despite traditional beliefs about what is termed the Nature of Science (assumptions which still tend to hold popular sway in many people's limited science literacy, even while contemporary scientific thought has begun to challenge such notions), 'Science' cannot be treated as an abstracted, pure entity. 'Science' is not Knowledge arrived at through dispassionate, objective procedure; science is embedded in cultural systems and social meanings that are shaped by preferences, by prejudices, and by the sedimented limits of routinised belief that have long kept women in science on the margins of the historical record.

Chapter Three - Exploring the Influences: Writing Science, History, and Women.

Any collection of fiction is influenced by a variety of other literary sources. My thesis, as a collection of short stories, based on the lives of selected women of science throughout history, was influenced by authors who write short fiction based in science and history, and those who address feminist issues and highlight women in their stories. I was also inspired by authors and essayists who experiment with the traditional form of narratives and choose instead to play with the ways in which stories can be told. In this section I will be discussing some of the literary influences relevant to *And Other Scientists*: *Stories of Women in Science,* in regards to the formation of the stories that I chose to write, the creation of scientific and historical narratives, and the representation of women in STEM.

The choice to use short stories in my thesis collection, as I have indicated in Chapter Two, was purposeful. The flexibility of the short story genre is something that I only came to appreciate in my undergraduate studies, in a course where Andrea Barrett's short story collections *Ship Fever* (1996) and *Servants of the Map* (2002) were explored in the context of historical fiction (both real and imagined) and creating realistic characters. Barrett uses the form of short fiction to weave stories of the past and present into genealogical timelines, exploring narratives of women, science, and family. For my research project I turned to her stories once again for inspiration, as Barrett makes use of short fiction in order to convey a series of semi-truthful historical narratives. She is an example of how literature can be used to fictionalise history and science in ways that are approachable and contemporary. In stories such as "The Littoral Zone" and "Servants of the Map", Barrett explores scientists, geologists, and cartographers as they make discoveries, discuss theories, and form personal relationships. These stories serve to humanise scientists, providing relatable backgrounds and experiences that allow the reader to

see them as someone they understand and empathise with, while also learning something about scientific discovery. For example, "The Littoral Zone" explores the story of two scientists, Jonathan and Ruby, who stay at a marine biology research centre for three weeks. Both happily married, with children, the two are focussed on scientific discovery, teaching students, and attending lectures from fellow scientists (*Ship Fever* 47). Barrett casually includes scientific terms, scientists' names and study areas, and information about marine life in a way that advances the romantic plot between the two main characters. Her use of science is unaggressive and unassuming, intent on normalizing terms and a world of difficult ideas that, in the context of Jonathan and Ruby's work at the centre, appear simply as an integral part of life for scientists.

The method in which Barrett approaches science in these stories was a significant influence for my stories, as I wanted to emulate how she moves away from mistaken popular portrayals of scientists as remote, robot-like figures that work in laboratories. Instead, Barrett depicts scientists as the humans that they are, and their work as entangled with the claims of the everyday. The emotional aspect of characters was a driving factor for me, as women's characters, in particular, in scientific spaces are often judged on emotion; either reported as cold and emotionless by their male colleagues, perhaps because women are defensive about their position in a male-centric workspace, or as overtly over-emotional and therefore unable properly to perform the demands of conventional science in a logic-based environment. Rosalind Franklin, for example, was often excluded for being a woman in university and in the workplace throughout her life (Oudenhoven). While men and women alike, in a scientific setting, are frequently seen as existing beyond the parameters of familiar daily life, living in strange science labs with chemicals and machines, women seem to suffer more for even attempting to be human. In 2005, the president of Harvard University made a speech in which

he noted that women could never rise to a ordinate positions in science because they do not want to give up their families or their time for the challenges which a higher position entails (Goldenberg). Conversely, women who choose not to have families are seen as selfish and bizarre, too intelligent for love. Unlovable.

In relation to short stories and the way that Barrett represents scientists, I wanted to show that while scientists are making discoveries and researching existing mysteries or empirical challenges, their day to day life is not mysterious; they are humans living human lives. Barrett's short fiction shows this side of science, the lives outside of the research – or indeed the lives lived in relation to the research - and the treatment faced by all involved. I do not mean to pretend that the exclusion and treatment of women in the workplace does not exist, in fact I wish to highlight this, but I also on a wider scale hope to show that scientists' lives are complex and diverse, both inside and outside of the workspace. In this regard, I made an attempt to show routine elements of life in the stories that I wrote; from Cecilia Payne-Gaposchkin's daydreams about her past experiences, Anne McLaren's relationship with her then husband and children, and Gladys West's childhood moments and teaching experiences.

Another historical and scientific literary influence was Andrea Wulf's short story collection *The Brother Gardeners: Botany, Empire and the Birth of an Obsession* (2008), a book which explores the lives of six men who were a part of the eighteenth-century popular plant-collecting revolution, including Carl Linnaeus (who created the modern method of plant classification) and Phillip Miller (author of *The Gardeners Dictionary* (1731), a book detailing the methods of cultivating plants). Wulf's novel, though male-centric and therefore existing in opposition to my own collection, demonstrates a more science-centric approach than Barrett's story-based fiction. Wulf does not shy away from the botanical sciences that the men were exploring, but

her stories do not devolve into the abstracted, fact-based narratives that Clough presents in his proposed “science stories”. Wulf seems to have, in my opinion, found the balance between the hard facts of Clough’s stories (which illustrate the Nature of Science) and Allchin’s science “myth-conceptions”. In my story “YOU HAVE ARRIVED”, based on the life experience of Gladys West, a mathematician whose work with satellites paved the way for modern GPS, I intended not to shy away from the science involved in her work. Mathematics is notoriously a field that does not often feature in literary language and fiction. Therefore, though I wished to give Gladys a story that explores her influences, her background, and her motivations, I wanted to also make space for the science that made up a large part of her life. She went back to university multiple times, including two years ago in 2018 when she received a PhD via online study, and mathematics was clearly a passion; therefore for me to have removed too much of the science would have detracted from, even eviscerated, the subject of the story. Drawing on Wulf’s ability to write scientists into a narrative that reads as engaging story rather than as illustrative, lesson-based fact, I chose to include a section that explores the science, albeit in a creative way, so as to emphasise that the story is not just about her life outside of the laboratory. West’s story is also represented through transitions, periods and moments of her life, separated by mock GPS directions - as she was an integral part of the development of this technology. Her life was full of many twists and turns – as mentioned above she went back to study several times, she found various jobs, and moved between different projects – and I felt that though she did not have GPS technology during her working years, the routes she would have pathed would have been vast and interesting, thus I elected to represent her story using the mode suggestive of GPS, albeit that this is an historical anachronism. The point is also served in that the very form of the narrative mode also works repeatedly to bring to mind the scientific innovation for which we have West to thank.

Another aspect of Andrea Barrett's stories that I drew on for inspiration is her interest in multi-modal forms of narration. For example, Barrett often uses non-traditional elements into her stories as a way to creatively embrace the many forms that literature can take and further the impact of a story. For example, "Servants of the Map" is told through letters to a wife far away, "Theories of Rain" intersperses question and answer segments from a science textbook with diaries entries from the narrator, and "The Marburg Sisters" involves a dream-like narrative between a faceless questioner and the narrator's answers. Using a non-traditional narrative allows for a different kind of story to be told. There is often more to be said or intuited through the additional viewpoints that are allowed by the extras – the diary entries, the snippets of a letter, quotes from a book – than could be carried by a more conventional narrative unfolding. Experimentation with form played a large role with my collection of stories, particularly because the narratives are centred on science. In literature we often see stories that proceed in an organised manner, made up of "chronologically ordered scenes" (Singer 10). Narratives tend to stick to a strict schedule, a chronological structure that is understandable and almost always the same. However, scientific discovery and modern technology are always adapting and changing, providing us new ways of doing things, seeing things, and experiencing things. Therefore, to engage with science in literature there is a sense that one needs to experiment with literature as science does with our experience of life. For example Lawrence Sutin, in his essay "Don't Let Those Damn Genres Cross You Ever Again!", creates a small archive to showcase some authors from history who chose to mix and play with genre and form, such as Fyodor Dostoevsky who, in his periodical *A Writer's Diary* (1873-76), "merged political journalism, literary essays, memoir slices, and short stories" to form a strange and passionate amalgamation of his thoughts (22). Sir John Mandeville, author of *The Travels of John Mandeville* (1355), similarly played with genre and form, weaving a tale of myths, geological and zoological facts and ideas, and his thoughts on humanity into a strange piece that is a both

true and false in various parts (Sutin 23). Experimenting with genre and form is clearly not something new, it has a long historial lineage, when we know where to look, but for the contemporary writer who is interested in discovering innovative routes into narrative, it can have much more of an impact than the familiar structures of traditional narrative.

Nevertheless, some of the short stories that I constructed *are* more traditional, namely those of Cecilia Payne-Gaposchkin and Maria Sibylla Merian. These two stories mainly take the form of a singular normative narrative, although Merian's story is told via diary entries from her daughter Dorothea (to highlight how both women played a role in the work of scientific illustration), while Payne-Gaposchkin's story begins with a dream narrative and also includes a developing and changing look at the abstract of the paper that she is writing. These two stories draw mainly on inspiration from Andrea Barrett and the way that she weaves scientific terms and ideas into other narratives. Being that I am not in the sciences myself, writing on the concepts of astrophysics and mathematics is not my innate strong suit, but by looking at how Barrett slides words and phrases into her stories that are understood through context and through the lenses of the characters, I tried to write lay science from the perspective of a scientifically informed writer for whom these concepts would not be foreign, but rather familiar discursive repertoires, and even daily conversations.

This also ties into the concepts that are mentioned above and in Chapter Two: how science in textbooks and the general population's understanding is not contextualised around human influence (Tobias 81). Scientists are often faceless, nameless, white-lab-coat-wearing figures who merely have the knowledge that we perceive as science, but by writing on these women and letting scientific knowledge roam in their complex minds and fall from their lips with ease, I hope I allow for an encouraging re-conceptualising of science within lived human contexts.

For yet other stories in the collection, I wanted to explore a more vigorously experimental form of short fiction and therefore I turned to China Miéville. His short story collection *Three Moments of an Explosion* (2015) is a masterpiece in strange, weird, and outside the box approaches to form (not to mention narrative). For example, Miéville's story "Listen to the Birds" was an inspiration for me, in the ultimate destruction of what a story is seen to be. "Listen to the Birds" is a second-for-second breakdown of a movie trailer, giving only the directions for what the viewer would be seeing if the story were a visual medium. For example, the opening lines read: "0:00-0:03 Two tiny birds fight in the dirt. There is no sound" (Miéville 392). It is a disorientating and initially disarming narrative, not just in terms of content, but in the dramatically defamiliarized, even unapproachable, format - the strangeness and impact of the story lies in its differences to what you expect from a short story. (Similarly, in Sally Ann Murray's poetry collection *Otherwise Occupied* (2019) the poem "Lady Gaga's Super Bowl Performance Divides America" tells a cultural story of femaleness via short phrases and sentences that read like tweets or comments on social media.) The idea of using a normally visual format for a narrative inspired me to play around with different ways of telling a story. For Anne McLaren, a British scientist who was a part of the first successful in-vitro fertilisation (IVF) of mice, I wanted to give her story a startlingly innovative structure and decided to write it in the forms of tweets. Though Twitter might not have been a part of her life (it came out just before her death in 2007) she was a very modern and forward thinking woman who, I like to believe, would have used Twitter if it had been available to her, and who might have used this social media form in ways that blurred the fields of science and the domestic. Her name on Twitter as the hashtag #annemclaren has become synonymous with women in science and the field of genetics, so I believe that encapsulating her story in a string of Tweets allows for her to become an active part of a community who now appreciates her work. The short form of

Tweets, at a maximum of 280 characters, is an interesting way to approach a short story as each Tweet needs to convey a thought and a part of the narrative. However, despite the short nature of Tweets I think that social media posts are a good way to gain insight into people's personality, in the manner that they engage with others and the words they choose to fill the short character limit. Therefore, this story was intended to show the process and the length of time that it takes for a scientific discovery to take place as well as to highlight that scientists are also ordinary people who have lives outside of science (as shown in her interactions with husband Don Michie, and the mentions of her own developing pregnancy throughout the story). Anne McLaren's narrative is also intended to show that not every woman necessarily experienced direct and documented oppression or exclusion because of her gender. While McLaren did not experience any negativity due to her gender (to my knowledge), she represents a large number of successful female scientists who are not known about by the general public in the way that male scientists often are.

Experimental short fiction also allowed me to explore more commentary than just the story of the woman I was focussing on. For Mary Anning, a fossil hunter and early palaeontologist, I wanted to explore the direct exclusion that she experienced throughout her life. While she was incredibly influential in finding fossils that had never been seen before and researched as much as she could on the creatures she had been discovering (despite her lack of access to education) she was never seen as an equal by the men who were doing the same jobs (Clary and Wandersee 153). Her discoveries were used liberally by men without acknowledgement of her contribution and as I have said, because she was a woman she was excluded from the Geological Society of London. It was presumed that because she was a woman it would be impossible for her to be a 'real scientist'. She died relatively unknown, with no recognition for her contribution to the field of palaeontology. In "Fossilised", the short story I wrote on Anning, I decided to show

the supposed fossilised ideas surrounding women and science, represented in a secondary skew-parallel narrative lying adjacent to or jaggedly enfolded within her story – much as fossils are formed in layers of soil and ground and time. These quotations are designed to represent the outdated idea of women not being able to do science. A fossilised idea, if you will. Yet as a reader passes through the layers of ideas, moving from citations taken from the 1800s through to the 2000s, to the final instance referencing 2017, it becomes clear that despite the progress made to change the negative widespread perceptions of women in science, there is still a bias against female scientists in the minds of (some) influential men in scientific fields today.

One author who has influenced me to share stories of strong women is Roxanne Gay. She has written many works that deal with the concepts of feminism and what it means to be a feminist, for example her collection of essays *Bad Feminist* (2014) and her memoir *Hunger: A Memoir of (My) Body* (2017). However, for my thesis I was inspired by her collection of short stories *Difficult Women* (2017). This collection includes diverse stories of women from different backgrounds, experiencing the world as women and the various struggles and joys that come along with that. The titular short story "Difficult Women" addresses different groups of women, namely Loose Women, Frigid Women, Crazy Women, Mothers, and Dead Girls (Gay 35-43). These groups are named for the adjectives often used by society to label women as deviant or lacking. Women who have multiple partners are labelled loose; women who refuse sex are frigid; women who are emotional are crazy. These stereotypes are placed on women, regardless of women's interiority, intentions or life experiences, and this creates damaging perceptions of women based only on outsiders' views of their lives. "Difficult Women" gives a different look into those stereotyped women, allowing us to see the other side of the stereotype (often given to the women by men), asking readers to reconsider our socially-inflected perceptions of these groups. For example, the Crazy Woman calls a partner multiple

times after a date because she has left her work briefcase, full of important documents, at his place. He brands her crazy to his friend, because she calls him so many times after only one date (Gay 39). The Frigid Woman struggles to emote and speak of her feelings, and is branded frigid by her husband for not being emotionally available enough, "the old ball and chain never put[ting] out" (Gay 37). There is no discussion between her and her husband about her emotions, there is only immediate judgement. This is a pattern that many women have experienced, judgment placed immediately without any discussion of reason.

The idea of women being branded as a stereotype and judged on their outward demeanour reminded me of the stories that I read of Rosalind Franklin, labelled often as cold, unemotional, and as someone who did not care for her appearance. James Watson, one of the men who used her photograph in the landmark paper on DNA structure, mentions her in his book *The Double Helix* (1968) noting that "[she] did not emphasize her feminine qualities. Though her features were strong, she was not attractive and might have been quite stunning had she taken even a mild interest in clothes … Unfortunately … there was no denying she had a good brain" (Watson qtd. in Rapoport 320). He also added that her headstrong behaviour meant that her supervisor felt threatened by her and that she therefore "had to go or be put in her place" (Benderly). She was not taken seriously because she was a woman, but the fact that she was a 'frigid' woman made it worse to the men around her. There is a clear difference between the way men and women are treated in society and particularly in the workplace. In social circles men often avoid the judgement that women do. Men who have multiple partners have habitually received praise from their peers; men who lack emotional availability are often admired for being 'real men'. In the workplace we often see terms like 'bossy' and 'naggy' being used for women, whereas their male counterparts with similar traits are praised as leaders and individuals of influence and powerful. In my stories, I therefore wanted to emulate the

depictions of women given by Roxanne Gay, showing women from their own perspectives and not shying away from the problems that they have faced because of their gender.

Writing women, particularly addressing how women have been excluded from traditional historical archives and narratives, is not an easy task. Choosing who to write on and how to write these stories has led me to create the range of stories I have, partly experimental, partly conventional, partly non-traditional stories.

Another aspect that I had to acknowledge was that the women are not alone in their stories. Their stories are surrounded by, even entangle with, other life/stories that influenced them: the stories of their colleagues, their parents, their partners, and those within the ambit of their scientific work. Hence, as illustrative examples of this imbrication, the inclusion of Watson and Crick's narrative in Rosalind Franklin's story, conversations between Gladys West and her husband, interactions between Anne McLaren and her colleagues, and perhaps most significantly, for our South African context, Gita Ramjee's experiences of meeting women in HIV clinics across the country. When researching Ramjee's story one thing that stood out to me was how she spoke about her work in science with ordinary women. When visiting clinics and seeing the women who were being affected by HIV, domestic violence, a lack of sex education, and poor testing facilities, she felt that she was, as a woman and a scientist, situated in the right place. For many, an experience like this, meeting women who are suffering, would not have been rewarding, but Ramjee found a purpose and a passion for her work in creating changes in women's health. For this reason, in representing her narrative I wanted to include an imagined version of this telling, insightful moment in her understanding of the 'rightness' of her female science journey, making sure to highlight the women and their stories, since these female lives played an important part in her own story of being a woman in science.

Conclusion

And so: to conclude.

In part, I wish I could ‘conclude’. I wish that my findings spoke conclusively of dramatic positive changes in the historical record that give attention to the representation of women in science. Instead, I must leave my final pages open-ended.

There is no sudden recanting of historical error; no reassuring epistemological edifice to overshadow the existing Archive. Instead: I have tentative findings. Scatterings. Gaps. Faint gestures. Some short stories. And some Names.

But perhaps, it is possible to put a positive spin on such open-endedness. For surely the work I have been attempting is but preliminary and ongoing. I like to think that the open-endedness is a necessary way of making space: not only for those yet-to-be-discovered women of science who have gone before, but almost a hopeful, pre-emptive clearing of a way for those still to come. For such futurity *must* not prematurely foreclose if the multiple and emphatic places of women in science are to be properly acknowledged, and credited. I have tried to convey to my readers the very partial, selective nature of my undertaking, highlighting the fact that the achievements of innumerable women in science have been omitted. For every Maria Sibylla Merian or Gladys West or Gita Ramjee, there will be another woman whose life and work I have not included. Always another name uncovered by research, through a footnotes, hidden in the shadow of a spouse or colleague; it has been near impossible to make my own decisions of who to cut from this archive, when so many have been cut from the traditional archive before. Many times in this study I have been tempted, in relation both to the critical and the creative aspects of the project, to detour into another, necessarily unfinished undertaking: I have felt drawn to devise a ludicrously massive compilation of names, of all the women whose

stories of science I considered writing, with special niches and nameplates, lacunae and torn labels.

This endeavour could have derailed me. A mad, preposterous yet also maddeningly exciting effort of gathering, along the lines of an impossible Borgesian library, or a listing in the manner of Ivan Vladislavić. Extensive, if always unfinished, and never comprehensive, this Women's Archive is a gradually filled but importantly open and hopeful space for others. She who is yet to come. Call Her X, for the moment, if you like the neat affinity of the mathematical marker. Or, name her 'Judith', as Virginia Woolf once did, inventing for Shakespeare an imagined sister, to carry her feminist argument in the essay "A Room of One's Own" (1929). Her names might be many: call her Sibongile. Or Vaya. Or Shirley. Or Dorcas. Because we need these new names, and I must believe that, in the re-storying of science, they will come. I must believe this because in just this year, in just my limited research, in just the field of science, I uncovered a multitude of names.

Francis Rix Ames. Elizabeth Garrett Anderson. Mary Anning. Virginia Apgar. Hertha Ayrton. Alice Ball. Winsome Fanny Barker. James Barry. Patricia Bath. Elizabeth Blackwell. Jocelyn Bell Burnell. Rachel Carson. Rachel Chikwamba. Anusuya Chinsamy-Turan. Yvonne Clark. Gerty Cori. Marie Curie. Ingrid Daubechies. Jennifer Doudna. Sylvia Earle. Sherien Elagroudy. Gertrude Elion. April Ericsson-Jackson. Ozak Esu. Rosalind Franklin. Katherine Freese. Sophie Germain. Jane Goodall. Tiera Guinn. Alice Hamilton. Caroline Herschel. Dorothy Hodgkin. Grace Hopper. Mary Jackson. Shirley Ann Jackson. Mae Jemison. Katherine Johnson. Quarraisha Abdool Karim. Mary Beatrice Davidson Kenner. Stephanie Kwolek. Henrietta Leavitt. Ester Lederberg. Inge Lehmann. Rita Levi-Montalcini. Ada Lovelace. Wangari Maathai. Julie Makani. Hilde Mangold. Andriana Marais. Maria Goeppert Mayer. Brenda Milner. Barbara McClintock. Anne McLaren. Lise Meitner. Maria Sibylla Merian. Maryam Mirzakhani. Margaret Mungherera. Emmy Noether. Tebello Nyokong. Francisca

Nneka Okeke. Alice Parkern. Carolyn Beatrice Parker. Cecilia Payne-Gaposchkin. Gita Ramjee. Sally Ride. Vera Rubin. Alta Schutte. Mary Schweitzer. Sara Seager. Susan Solomon. Mary Somerville. Himladevi Soodyall. Helen Taussig. Valentina Tereshkova. Marie Tharp. Valerie Thomas. Karen Uhlenbeck. Dorothy Vaughn. Patricia Joan Vinnicombe. Gladys West. Elsie Widdowson. Maria Wilman. Maria Winkelmann. Jane Cooke Wright. Sau Lan Wu. Chien-Shiung Wu. Tu Youyou.

…the names are unending, overwhelming; representative of the many more whose names and stories may never be uncovered.

Additionally, instead of seeing my brief Conclusion to the research component as a final means to resolve, or to reach The End, I prefer to imagine that the very varied form of the contemporary short story – with shifts away from wrapping up loose ends, or reaching denouement, or pushing readers towards moral understanding of insightful epiphany – intersects admirably with the critical and creative nature of my study. I have written stories of the lives in science of several female scientists whose lives are now understood, however belatedly, to have exerted a significant influence on scientific discovery. Maria Sibylla Merian, a naturalist and scientific illustrator who was the first to document the process of metamorphosis in detail. Cecilia Payne-Gaposchkin, an astrophysicist and astronomer whose work changed the way that we perceive the physical makeup of the universe. Wangari Maathai, an ecologist whose Green Belt movement has helped to bring awareness to the devastating effects of deforestation. Mary Anning, an early palaeontologist who uncovered and documented fossils that had never been seen before. Rosalind Franklin, an X-ray crystallographer, whose photographs gave us the concrete knowledge to understand the structure of DNA. Gladys West, a mathematician who worked with early satellite data to map the earth and gave us the basis for GPS. Anne McLaren, a geneticist, who led the landmark study that successfully birthed mice fertilised via IVF. And Gita Ramjee, a Chief Scientists

Officer and medical researcher, who played an integral role in changing the way that HIV testing was performed in South Africa, particularly for women. I have attempted to work not only with story styles that borrow from conventional narrative patterning, but also to risk a few more experimental efforts, in which my formatting and method are suggestive of the scientific enquiries and challenges that these women faced.

Scholars are giving renewed attention to the need for an emphasis on the stories, roles, lives and contributions of women to science. In mid October, for example, under the still difficult, chastening conditions of the global Covid-19 pandemic, a call went out from researchers at the universities of Heidelberg and Bucharest, for participants in a 2021 virtual scholarly conference on the question of "Hidden Histories: Women and Science in the Twentieth Century" (Bonea and Nastasä-Matei) The organisers insist that the Academy acknowledge, taking to heart and mind, that female scientists actively continue to comprise 'missing persons' in scientific historiography, and they seek out ways in which to address – redress – both this shameful history and to effect complex understandings for and of this situation, so as to clear the way for future improvement. They argue that "the twentieth century has often been hailed as a period when women became important in science, but their participation in scientific inquiry and practice often remains buried, quite literally, in the footnotes of specialist publications and studies of the history of science. Even today, national statistics about women in science are not always easily available" (Bonea and Nastasä-Matei). Additionally, the "data that does exist suggests there is significant regional and cultural variation in how women engage with science globally" and "when we turn our attention to studies of the history of science in the twentieth century: the scientific pursuits of women in Western contexts have consistently enjoyed more visibility than those in regions like Africa, Asia or Eastern Europe. The Biographical Dictionary of Women in Science (2000) is emblematic of these trends, listing as it does a mere 17 scientists from India, China and Japan" (Bonea and Nastasä-Matei). The conference begins

"from the premise that encounters with science happened in a multitude of settings and that statistical data, while essential, provides only a superficial insight into the myriad experiences of women in science and, indeed, what science itself meant in different regional and cultural contexts" and they aim to "move beyond the popular 'heroine' model to investigate the many hidden figures who worked not only as professional scientists, but also at the periphery and even outside of scientific communities as lab technicians, amateur scientists, school teachers, librarians, journalists or science writers. In so doing, we hope to raise new questions and formulate new methods for writing the history of women in science. What, for example, do textbooks, forgotten footnotes in scientific papers, conversations about female colleagues in male scientists' correspondence or photographs of Indian women toiling at archaeological sites teach us about the history of women in science?" (Bonea and Nastasä-Matei). By own inclusion of women such as Wangari Maathai, an ecologist who is known more for her work in community engagement than pure science, and Maria Sibylla Merian whose scientific illustration may not present as real science, I intended to expand the idea of who a scientist is and what they can do. Beyond the othered science fields, the ones outside of traditional laboratories are those, as Bonea and Nastasä-Matei mention in reference to the conference, the assistants, the teachers, the librarians, the other contributors to the field of science who receive little, if any recognition, even by those in the same field.

Both in the creative work and in the apprentice research scholarship associated with the MA I have touched on questions such as those raised by this conference call. Among them are issues of gender and the unequal historiography of science in its theories, methods and archives; the pedagogies associated with science teaching and science education, and the gender-biased cultures of scientific practice and scientific communication. Overall, this has helped me to begin to address representations of women in science, and to blur the boundaries between

established and valued forms of scientific procedure, and the possibilities for women in science of other, less obviously scientific insights and relationships. My own MA project is a small attempt to engage with precisely such trenchant questions of alternative sources, methods and subjects, albeit on a limited scale.

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